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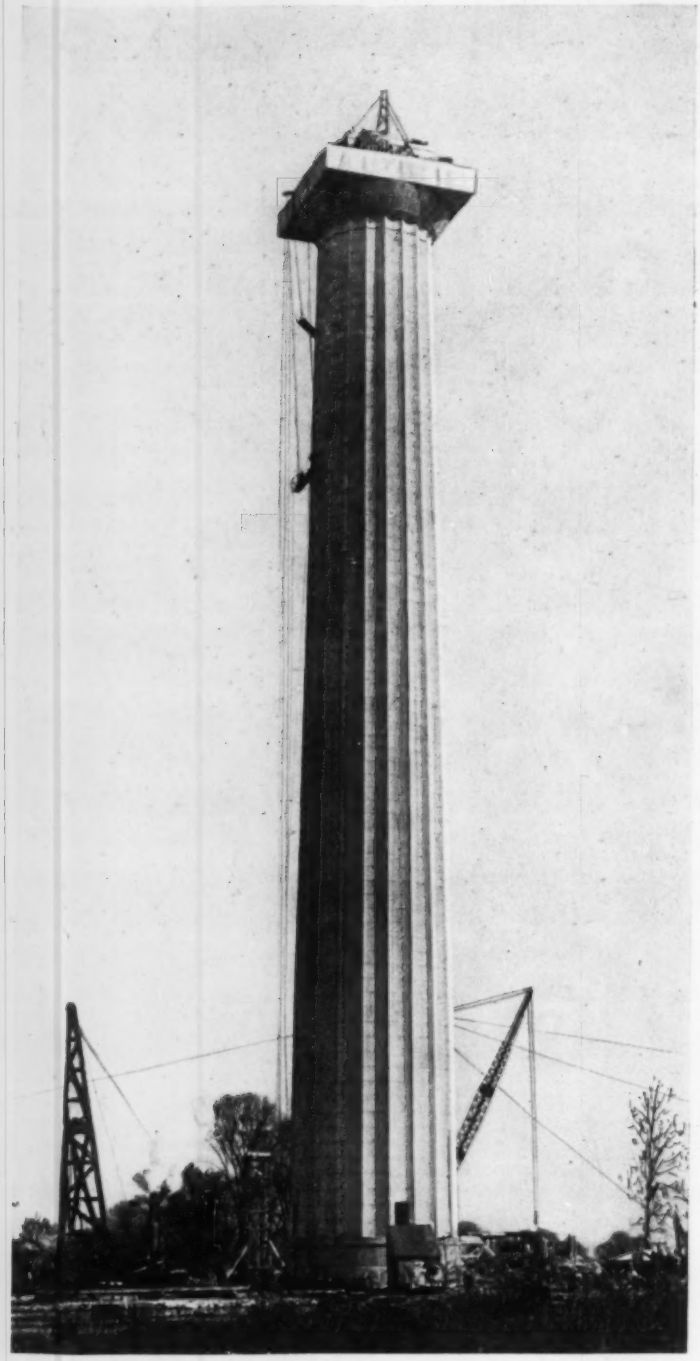
A MASTERPIECE OF BYZANTINE CONSTRUCTION—AQUEDUCT OF JUSTINIAN

Volume 1 — Number 14

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

NOVEMBER 1931



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DURING an impressive ceremony on October 24, the governors of New Jersey and New York officially joined the two states across the Hudson, when they cut a ribbon at the center of the George Washington Bridge between Fort Lee, N. J., and Fort Washington, at 179th Street, New York City. The completion of this bridge, with its 3,500-foot span, nearly twice the length of any other such span in existence, marks a great stride ahead in the art of bridge building. The design of this boldly conceived, yet simple, naturally graceful structure, adheres closely to the characteristic form of the early bridges of this type. That it is economical in the use of materials is evidenced by its light, shallow, and flexible system of stiffening trusses—weighing only 6 per cent of the entire dead load—the use of which resulted in a saving estimated at $10,000,000 in a $60,000,000 project. The Chief Engineer of the Port of New York Authority, O. H. Ammann, M. Am. Soc. C. E., has stated that with materials now available for cables, a modern suspension bridge with a span of 10,000 feet could be built with perfect safety.

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Among Our Writers

G. F. NICHOLSON spent two years on the construction of the Mexican Central Railway and two years on the location and construction of the Central Michigan and St. Paul Railway in the Pacific Northwest. In 1910 he became associated with the late Virgil G. Bogue, M. Am. Soc. C.E., and together they made investigations and reports on the harbors from Prince Rupert, B.C., to Astoria, Ore. During a long connection with the Port of Seattle, he built in 1918 the Smith's Cove Terminal, which was then the largest commercial pier in the world. For the past six years he has been Harbor Engineer of Los Angeles Harbor.

WALDO E. SMITH graduated from the University of Iowa in 1923 and has since specialized in hydraulics. After four years of field and office work, with the Burns and McDonnell Engineering Company and with Black and Veatch, Consulting Engineers of Kansas City, he taught mechanics at the University of Illinois. In 1928 he accepted an Associate Professorship in Civil Engineering at Robert College, Constantinople, but returned to the United States during the past summer to take up similar work at the North Dakota Agricultural College.

C. L. MCKESSON has been closely identified with street improvement work and with highway design and construction since 1910. For five years he was an assistant engineer in the office of the City Engineer of Los Angeles. After being overseas with the 23rd Engineers he returned to the United States to become Senior Highway Engineer in the Bureau of Public Roads, in charge of work in the Northwest. In 1924 he became Materials and Research Engineer for the California Highway Commission and since 1928 has directed engineering and research for the American Bitumuls Company.

GEORGE W. FULLER is a specialist on water and sewage purification, having devoted nine years after graduation to research in this field, both in this country and in Europe. For the past thirty years he has maintained consulting offices in New York, formerly in partnership with the late Rudolph Hering, M. Am. Soc. C.E., and now with James R. McClintock, M. Am. Soc. C.E. He has served over 150 cities in water supply and purification, sewage and sewage disposal, and valuation of public utilities.

DR. ING. TH. WYSS, of the Federal Testing Laboratory of Zurich, is a noted Swiss expert on the testing of materials. The results of his experimental work on reinforcing bars are made available to engineers in this country by ALBIN H. BEYER, Professor of Civil Engineering and Director of the Testing Laboratory at Columbia University.

H. P. HAMMOND, after teaching civil engineering at the University of Pennsylvania and at Lehigh University, was appointed in 1912 Assistant Professor at the Polytechnic Institute of Brooklyn, N.Y., and since 1918 has been Professor of Hydraulics and Sanitary Engineering there. For a number of years he was associated with Lederle and Provost of New York, on the design and construction of water supply systems. He was Associate Director of the Investigation of Engineering Education in the United States, Canada, and Europe, conducted by the Society for the Promotion of Engineering Education in 1924–1928.

WELLS N. THOMPSON is a graduate of the Massachusetts Agricultural College and of Cornell University. As Assistant Chief Engineer for the H. K. Ferguson Company, he was engaged in reconstruction work in the Tokyo-Yokohama district following the earthquake of 1924. From 1927 to 1931 he was Manager of the Japan Branch of this company.

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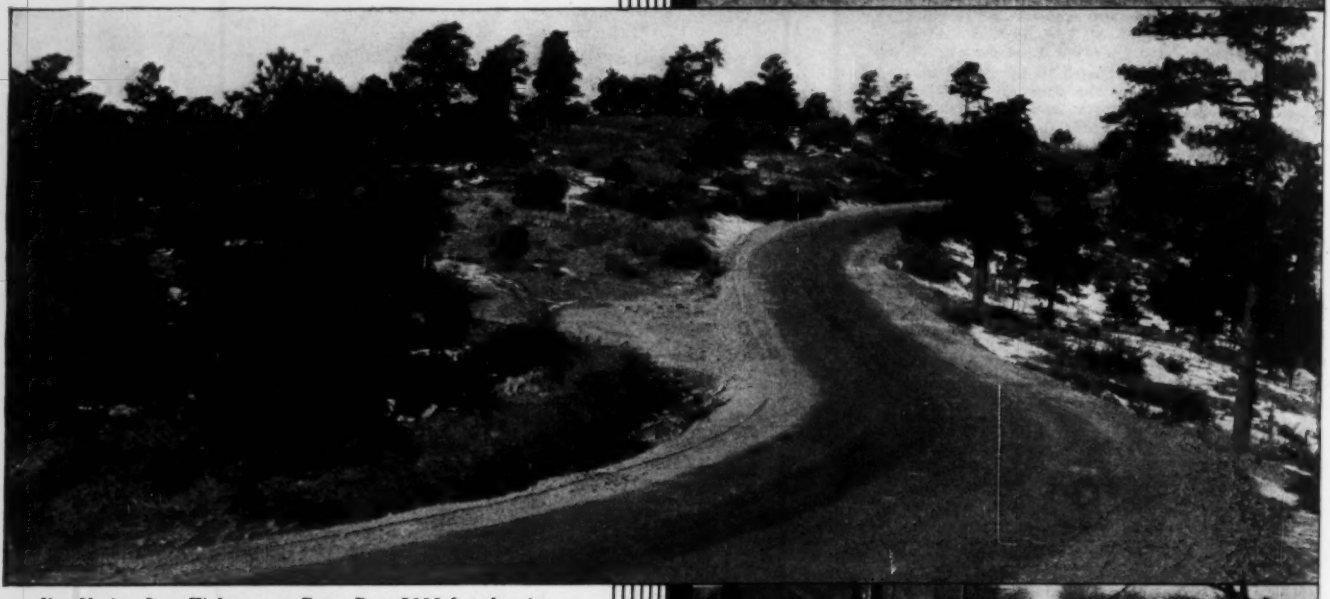

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Protecting Reinforced Concrete Against Deterioration by Sea Water

By G. F. NICHOLSON
MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
HARBOR ENGINEER, LOS ANGELES HARBOR DEPARTMENT, LOS ANGELES

CONCRETE piles are well adapted for marine terminal construction and they are now widely used for this purpose. However, it is becoming more and more generally realized that concrete, both plain and reinforced, deteriorates in sea water. In this article Mr. Nicholson details the destructive physical and chemical agencies that disintegrate ordinarily good reinforced concrete when it is exposed to salt water. He explains many treatments that have been tried with varying success to render concrete proof against these agencies and describes what apparently is proving to be a satisfactory method. This consists of impregnating precast units with asphaltum by a process similar to the better known vacuum pressure method used for the treatment of timber.

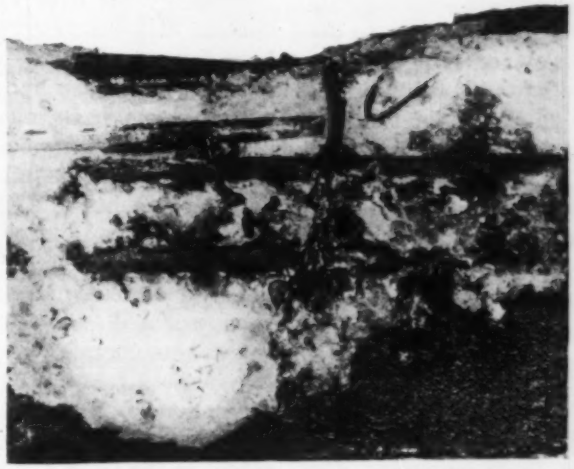
CONCRETE is the material to which the present generation must look to a large degree for permanency in marine construction, a fact chiefly due to the ready accessibility of all its ingredients and the low initial cost of construction. In recent years much talent has been engaged in trying to develop a permanent cement concrete which would be proof against all detrimental mechanical and chemical actions resulting from the presence of sea water. Although these investigations have entered every conceivable field of study, the results to date have been limited. The problem has been practically solved for some types of concrete construction, but there has not been a complete solution of the entire question of concrete disintegration which would be practicable from all standpoints, and generally applicable to all types of construction.

Deterioration of concrete in sea water is the result of numerous forces, which may be grouped into two distinct classes; disintegration due to mechanical action, and chemical decomposition. All the causes of deterioration, both mechanical and chemical, may be present at the same time in the average grade of concrete. These groups of destructive forces are usually cooperative in their attack and in their effects, one increasing the extent of the activity of the other, and vice versa. The seriousness of the chemical activity is usually proportional to the degree of physical disintegration which has taken place, and to the physical quality of the original concrete.

Regardless of its quality, surface concrete will suffer serious mechanical and physical disintegration due to the continued abrasive action of debris, ice, wind, and waves. Surface deposits resulting from the progressive carbonation of the lime and probably due to the carbonic acid content of sea water, constitute some degree of protection for most concretes. However, lime carbonate, which has a tendency to seal the surface against more active chemical agents, is reduced to ineffectiveness by the abrasive agents.

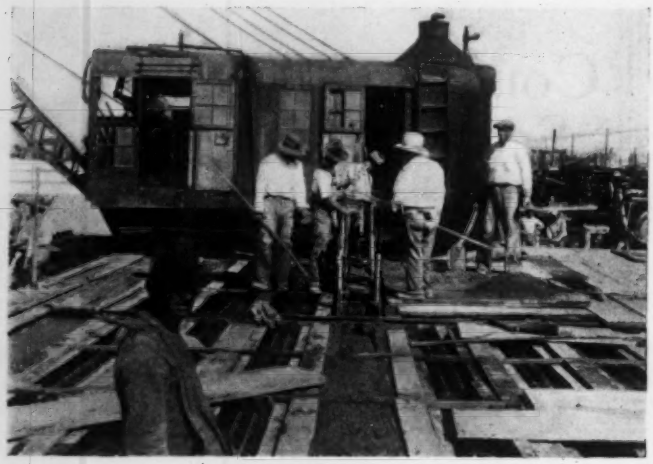
In a cold climate, the small quantities of water which enter the pores or interstices of the concrete within and below the tidal range will freeze and as a result will increase in size approximately 10 per cent. This expansion is certain to burst the confining passages, providing greater access to sea water and further destroying the concrete.

Crazing and hair cracks caused by the shrinkage which takes place in concrete on reduction of its moisture content; cracking due to changes in external temperature and to differences in temperature between the surface and the interior; handling cracks, difficult to eliminate in all precast units; and tension and shear cracks, which develop coincident with cross bending when reinforced concrete is used in compression at unit stresses sufficiently high to make an economical design; all provide entrances for sea water, thus furthering chemical destruction.



CORROSION IN UNTREATED CONCRETE PILING
Municipal Pier No. 1, Los Angeles Harbor

The deterioration which takes place in constantly submerged concrete constructed of good materials, with proper workmanship and correct mix, is much less than that occurring at about half tide or immediately above the tidal range, for the reason that the number of causes of failure is greatly reduced. However, sources of deterioration still remain, so that it cannot be said that such concrete is immune to attack when constantly submerged. Nor is the alternate wetting and drying of concrete limited to the portions of a structure within the tidal range. The surface for a considerable distance above high tide is subjected to spray, waves, and to moistening by capillary action. The evaporation of this sea water gradually builds up crystalline deposits in the facial interstices, and the expansive force of this action is sufficient to cause the formation of surface checks, purely by mechanical force.



CASTING A CONCRETE BEARING PILE
Parting Plates Between Core and Jacket Concrete Shown

CHEMICAL DECOMPOSITION

The chemical processes which take place during the hydration of the cement in concrete may be substantially characterized as a decomposition of the higher lime silicates into lower silicates and calcium hydroxide. The calcium hydroxide is easily recognized under the microscope as crystallized grains of various sizes evenly distributed throughout the mass. They add greatly to the strength and water-tightness of the concrete, but are soluble in water. It is this solubility, to the amount of about one grain per liter, that is an important cause of deterioration. The water seeps through any existing pores or cracks in the concrete, dissolves the calcium hydroxide, and carries it in solution out to the surface, where it often combines with the carbon dioxide of the air and becomes visible as a white efflorescence of carbonate. Chemical analyses have proved that the average hydrated portland cement contains from 13 to 17 per cent of calcium hydroxide.

Continued decomposition of the hydrated lime compounds, and of the clinker grains remaining after the hardening of the cement, may be characterized as a second stage of deterioration. By these processes new quantities of calcium hydroxide are generated, which in turn are carried out of the structure by the percolating water. The dissolving of the free calcium hydroxide and the decomposition of the silicates and other lime-bearing compounds of the cement go on contemporaneously; but the rate of the first process is far more rapid than that of the second. After some time in service, the period depending on the porosity of the concrete and the rapidity of the circulation of water in it, the total amount of hydroxide will have been lost. The decomposition of the lime-bearing compounds may continue until a complete breakdown of the cement takes place.

Added to the general deterioration of the concrete itself is the interaction of the magnesium sulfate contained in sea water and the calcium hydrate, or so-called free lime, of the concrete. Among the products of this reaction is another compound, calcium sulfate, which replaces a portion of the calcium hydrate of the cement. The calcium sulfate molecule is slightly larger than the original calcium hydrate molecule and consequently a swelling takes place during the reaction. Thus there is a twofold attack, mechanical and chemical, acting to produce the same result.

This progressive action continues unobtrusively until the reinforcing steel in the concrete is exposed either to the air or to oxygen-bearing water. Visible, rapid, and excessive corrosion immediately begins. When oxygen becomes available to the reinforcing members—either the dissolved oxygen in the water or the free oxygen in the air—the steel immediately starts to oxidize or corrode. Rust, the product of oxidation, occupies from 12 to 13 times the original volume of the steel, and forces the concrete to yield additional space, with a slow but tremendous pressure said to be about 4,700 lb. per sq. in. Cracking, which in the earlier stages can be seen only under a microscope, now becomes readily visible, and the cycle of accelerated action continues.

In his *Industrial Chemistry*, Dr. Henry K. Benson states that still another chemical action may take place in portland cement exposed to sea water. The action of the sulfates in sea water on the tri-calcium aluminate content of concrete results in the formation of calcium sulfo-aluminate. On crystallizing, this compound takes up a large quantity of water, producing a great increase in volume and destroying the cohesion of the cement.

MAKING PERMANENT CONCRETE FOR SEA WATER

Probably the most extensive efforts toward the production of a concrete immune to deteriorating agencies have been made in an endeavor to produce special cements which, when hydrated in concrete, would contain only non-soluble chemical combinations free from attack by any of the compounds existing in sea water. Scientific literature is full of the history of such efforts. Natural cements as well as portland cements have been altered by the addition of pozzuolana, which, in combination with the free lime released in setting, forms an insoluble cement material. The resulting products have been proposed and used with varying degrees of success.

Cements containing enough silica to combine with all the released free lime, thus eliminating opportunity for the action of the magnesium sulfate in sea water on the lime, apparently have not been tried commercially to any extent in the United States. In this country most of the deposits of silica in the proper form are at remote locations. This fact, combined with the limited commercial

use of the product in comparison with the huge demand for portland cement, has no doubt been influential in preventing the development of a cement such as that sought. The possibilities of its being placed on the market are very remote.

Even the most uniform of portland cements shows, upon setting, widely differing percentages of free lime and calcium compounds. Until still further research determines the exact chemical actions that take place in the setting of portland cement, and until different brands and different lots of the same brand show corresponding percentages of the various compounds in the hydrated cement, it can hardly be expected that definite quantities of pozzuolana can be mixed with cement to give uniform results. It seems, therefore, that commercial cements are certain for many years to contain a percentage of materials which even under the most favorable circumstances will be subject to the action of sea water.

On the other hand, the Pacific Coast regions contain bountiful deposits of pozzuolana, the value of which, when united with cement for use in sea water, has been clearly enough demonstrated in Europe. Therefore an extensive study of this product by the largest users of concrete in marine work on the Pacific Coast seems justified, looking toward the commercially economical development of portland-pozzuolanic cement mixtures.

The fact that the oxidation of reinforcement greatly accelerates the deterioration of concrete might suggest the use of painted or galvanized reinforcing steel, or of special rust-resisting alloy steels containing a high percentage of chromium. Because of the reduction in mechanical bond resulting from paint or zinc coatings, and the electrolytic action which takes place between the zinc and the steel in galvanized rods, the first two types of reinforcement are not practicable. As regards chromium steels, their manufacture has not yet reached the point where such rust-resisting alloys can be economically substituted for ordinary steel.

SURFACE, INTEGRAL, AND MEMBRANE WATERPROOFING

In an endeavor to protect concrete from the action of sea water, large numbers of waterproofing agents have been tested, with varying degrees of success. The usual method of applying a surface coating of water-resisting material is dependent for its success entirely on the stability of the material applied and the tenacity with which it adheres to the concrete.

Numerous tests by various engineers have shown that a thin coating of paint or preservative on concrete is effective only for a short time. It is practically impossible in applying such a coating to secure sufficient bond with the concrete surface for any degree of permanence.

The theory of integral waterproofing is that a stable admixture may be added to the concrete in such proportions that it not only will create a more workable mix, but also will render the concrete comparatively impermeable and non-porous with considerably less effort than if only the usual aggregates are used. The integral waterproofing agents which have been tried with varying degrees of success include lime, clay, diatomaceous earths, pozzuolanas, soaps, tars, emulsions, plastic or so-called waterproof cements, and barium salts.

Conclusions from a number of tests on different types of admixtures, containing both nominal portland cement and high early strength portland cement, were recently presented by Prof. Duff Abrams, Research Director for the International Cement Corporation. In brief, his conclusions were that the workability of concrete as measured by the flow test was not improved by admixtures; and that the admixtures tested should all be classed as injurious adulterants because of the excess water required to maintain workability, and the resulting reduction in the strength of the concrete, which is proportional to the amount of excess water.

TREATMENT PLANT AND CASTING YARD FOR THE MANUFACTURE OF ASPHALT IMPREGNATED PILING
Los Angeles Harbor Department, San Pedro

A method of protecting concrete with a waterproof membraneous coating has been developed by which concrete piles or other precast units are poured into an outer shell of asphalt cement. Prior to this pouring, bonding stones are cast in the asphalt cement in such a way that approximately half of each stone is embedded in the asphalt and the other half projects. The concrete is then poured against the bonding stones, and in the case of piles or pipe the entire unit is spun at high speed to cause the concrete mixture, by centrifugal action, to thoroughly bond to the asphaltic coating. The result is a completely waterproofed unit of dense concrete, effectively sealed, as long as the coating lasts, against undue shrinkage or temperature cracks and against sea water. However, this process has been rather limited in its use, and it involves the problem of deterioration of the coating under mechanical wear.

For protecting the under side of concrete wharf decks, beams, and girders, a similar process has been adopted, particularly at San Francisco Harbor. In general, the procedure consists of placing roofing paper against the inside of the forms for the concrete wharf structure; pouring a layer of asphalt over it; and sprinkling gravel or crushed rock of proper size on the asphalt surface so that it penetrates the asphalt for about half the average diameter of the aggregate. Concrete is then poured against the hardened asphalt and thoroughly bonded to it by the projecting aggregate.

IMPREGNATION METHOD GIVES GOOD RESULTS

In 1920, at Los Angeles Harbor, the idea was advanced of completely impregnating concrete by means of simple immersion in a bath of hot asphalt, at a temperature of

from 450 to 500 deg. fahr. for a period of from 15 to 24 hours, producing what was known as "duocrete." This process was designed to release the free water contained within the concrete so that in cooling the vacuum formed within the voids would serve to draw the liquid asphalt well into the body of the mass. The result sought and usually obtained was full impregnation. The chief objections to this treatment were the high destructive temperatures involved and the fact that a porous, lean-mix concrete was essential. Loss of strength in already weak concrete and failure of bond on reinforcing steel were the inevitable results. The process did not prove satisfactory and has been discarded.

After further experimentation this treatment was developed into a vacuum-pressure process, similar to that used in creosoting lumber. In this method, strong dense concrete is subjected to comparatively low temperatures, the maximum being 260 deg. fahr. The latest treatment for reinforced concrete, here described, has been developed only for use on bearing piles, sheet piles, and other precast concrete units which are small enough for transference to the impregnation chamber.

First, a dual-mix monolithic piling is cast, as shown in Fig. 1, having for the core section a high-strength concrete which develops a compressive strength of from 4,000 lb. to 5,500 or 6,000 lb. per sq. in. This is surrounded in the more vulnerable section, which extends to at least 3 ft. below extreme low tide, by a drier but equally strong jacket or shell $1^1/_2$ in. thick. Compressive strengths of as high as 7,200 lb. per sq. in. have been attained in the core concrete. Both jacket and central core are cast at the same time by the use, during the tamping process, of vertical steel plate separators, which are progressively withdrawn as the casting approaches completion. During the casting air hammers are used to vibrate the forms and insure a concrete of maximum density.

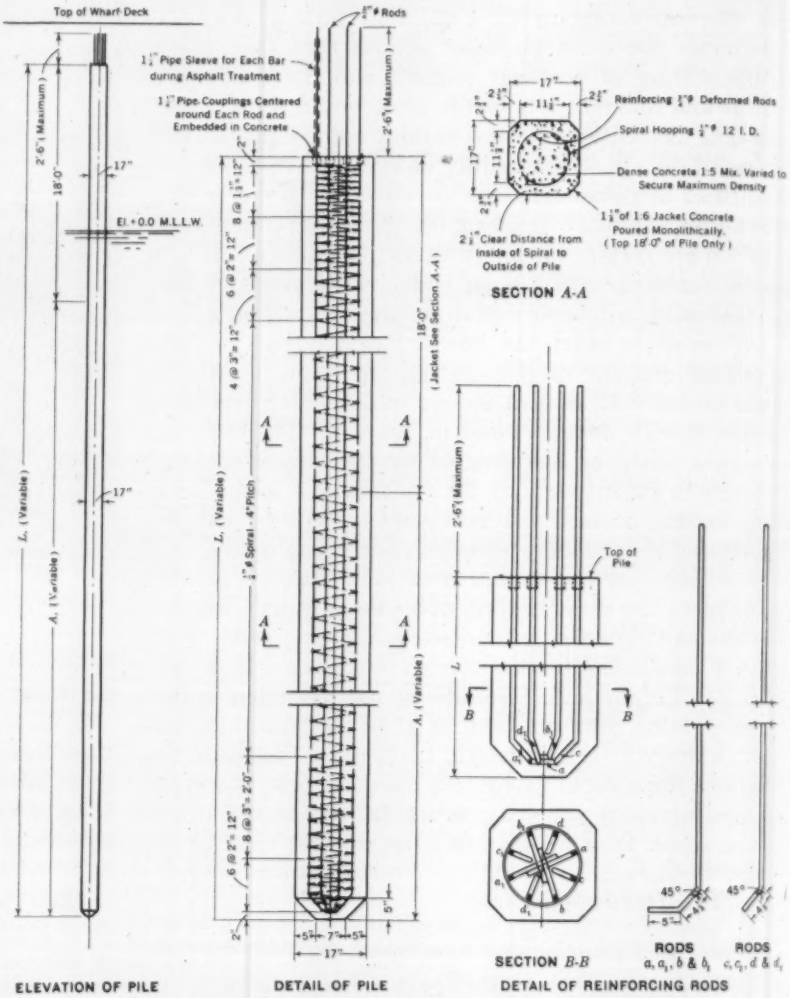

Top of Wharf Deck
1¼" Pipe Sleeve for Each Bar during Asphalt Treatment
1¼" Pipe Couplings Centered around Each Rod and Embedded in Concrete
2½" ϕ Rods
2'-6" Maximum
18'-0"
17"
El. +0.0 M.L.L.W.
L, (Variable)
A, (Variable)
6 @ 2"= 12"
8 @ 1½"= 12"
4 @ 3"= 12"
¼" ϕ Spiral - 4" Pitch
8 @ 3"= 2'-0"
6 @ 2"= 12"
5"
2"
5½" 7" 5½"
17½"
(Jacket See Section A-A)
Reinforcing ¼" ϕ Deformed Rods
Spiral Hooping ¼" ϕ 12 I. D.
Dense Concrete 1:5 Mix, Varied to Secure Maximum Density
1½" of 1:6 Jacket Concrete Poured Monolithically. (Top 18'-0" of Pile Only)
2½" Clear Distance from Inside of Spiral to Outside of Pile
SECTION A-A
Top of Pile
B
45°
5"
RODS a, a1, b & b1
RODS c, c1, d & d1
ELEVATION OF PILE
DETAIL OF PILE
SECTION B-B
DETAIL OF REINFORCING RODS

FIG. 1. PRECAST ASPHALT IMPREGNATED CONCRETE PILE
60-Ft. Piles Lifted at Four Points; Longer Piles Lifted at Five Points

Every means possible, such as designing the mix for maximum density, controlling the mixing, water content, pouring, tamping, and curing is observed in the effort to obtain, for the body of the pile, concrete that will normally be practically non-porous and impervious to water. The preferred mix for the core section, proportioned for the utilization of materials available at Los Angeles Harbor, where this type of treatment has been developed, approximates 1 part of cement, by volume, to 5 parts of graded aggregate, fine and coarse measured separately. The maximum quantity of water per cubic foot of cement is limited to 52 lb.; and the slump of the mixture to 2 in. The coarse aggregate of the jacket concrete must all pass through a $^3/_4$-in. screen. With the materials usually available, the mix will average 1 part of cement, by volume, to 6 parts of graded aggregate, with only sufficient water to thoroughly moisten the mixture, in no case more than 42 lb. per cu. ft. of cement.

After being thoroughly cured for a period of not less than 60 days, the piles are loaded on four-wheeled steel carriages, and drawn on a carefully leveled track into a draft-tight preheating or tempering chamber. They are then subjected to a dry-air treatment for a period of from 18 to 20 hours, during which time, in order to avoid setting up any undue stresses in the piling, the temperature in the dry kiln is gradually and uniformly increased at a rate not to exceed 11 deg. fahr. per hour for 16 hours. It is raised from normal—from 80 to 100 deg.—to 240 deg., or a maximum of 250 deg., at the expiration of the 16-hour period.

A uniform temperature of 240 deg. fahr., not to exceed 250 deg., is then maintained for not less than 2 hours and not more than 4 hours. At the end of the drying period the piles are moved as rapidly as possible—to avoid cooling them—into the main treating cylinder, which has been preheated and further dehydrated under a 26-in. to 28-in. vacuum from the time the cylinder doors are closed until the asphalt has been introduced and has completely submerged the piling in the chamber. The purpose of the preheating and the vacuum is to temper the piling and rid the shell and the exterior of the body of the pile of a large quantity of their free water, and to produce a high vacuum in the voids thus created. The temperatures are insufficient to release

an appreciable quantity of the combined water of crystallization.

Grade D asphalt, thoroughly dehydrated, having a penetration of from 0.40 to 0.50 cm. and meeting the specifications of the American Society for Testing Materials, is admitted into the treating chamber at a temperature of approximately 250 deg. fahr., and the vacuum is maintained throughout its introduction. After the chamber has been filled with asphaltum, the vacuum is replaced by air pressure of not less than 150 lb. per sq. in. and preferably 175 lb. per sq. in. This pressure is maintained for from 12 to 14 hours. The temperature of the asphalt surrounding the piling is maintained at approximately 250 deg. fahr. for the first hour, after which it is allowed to drop gradually, at a rate not to exceed 11 deg. per hour, until it reaches 200 deg.

After its temperature has been reduced to approximately 200 deg., the asphaltum is either withdrawn or is left in the treating chamber until the end of the pressure period. The piles are then allowed to cool to normal temperature, either in the pressure cylinder or in a draft-free cooling kiln to which they are quickly removed. This cooling process, which is controlled within 10 deg. per hour, may be likened to annealing. Both the preheating and the cooling periods are carefully controlled. The actual concrete temperatures are observed and recorded by means of a 6-ft. pilot-piling section in which electrical thermometer units are embedded.

The method of impregnation described is designed to produce approximately a penetration of from $^1/_4$ to $^3/_8$ in. in the main body of the pile, and of $1^1/_2$ in. in the portion bearing the drier mixed shell. The smooth, shiny, dense surface on the body of the pile resulting from the laitance of cement and water drawn to the formed surface, materially reduces the total asphalt penetration, and the absence of this surface on the core concrete, which is surrounded by a jacket of drier mix, permits additional penetration of the core in that section.

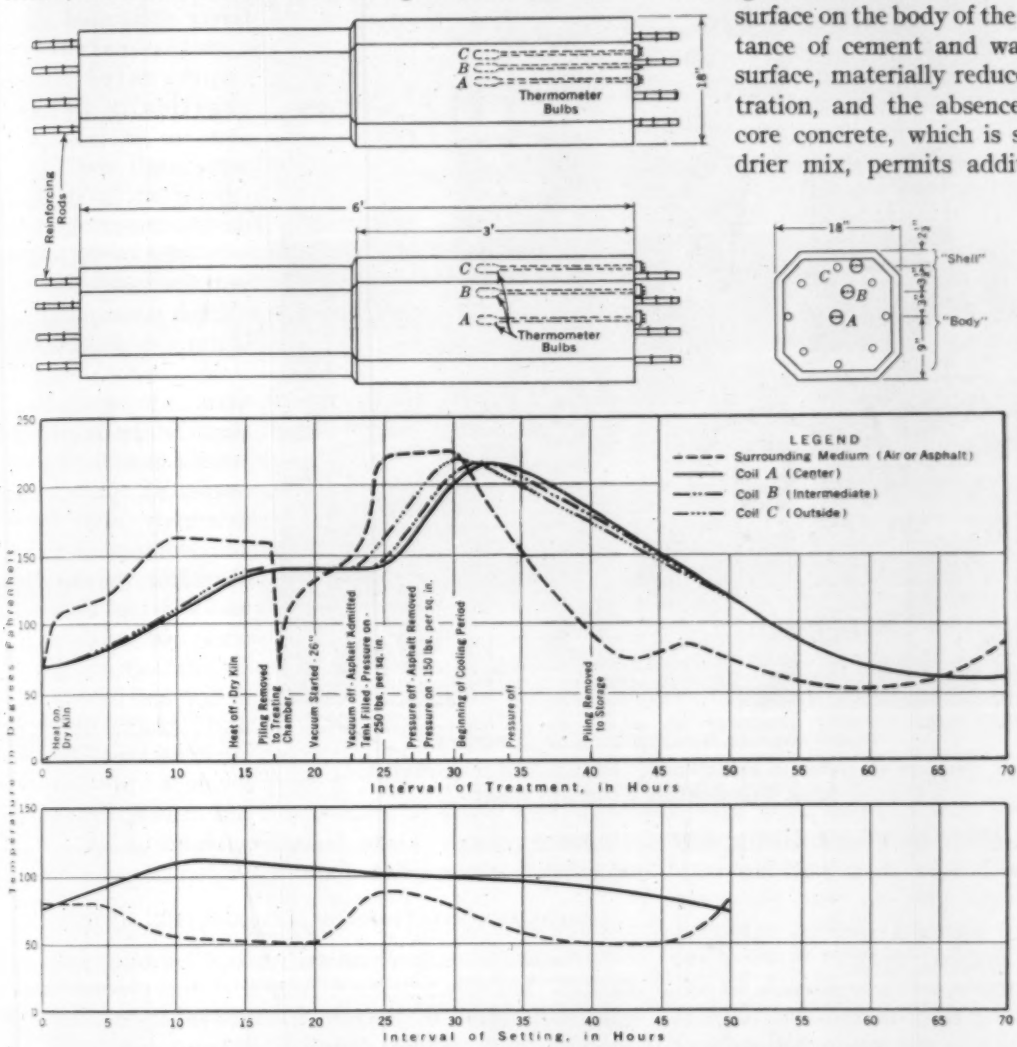


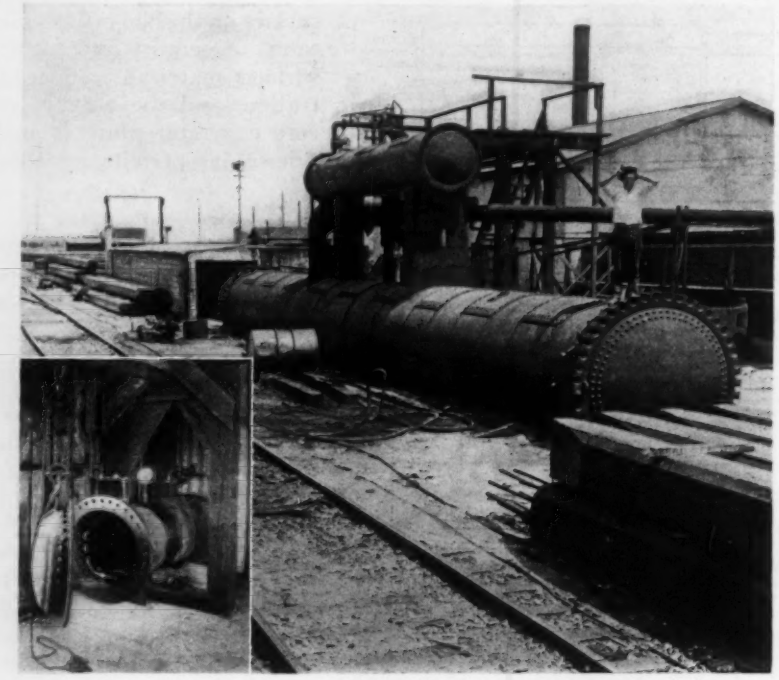
FIG. 2. THERMAL CHANGES IN A PILE DURING SETTING AND TREATING
Careful Cooling After Treatment Prevents Cracks and Spalls

This asphalt impregnation treatment of precast concrete units has been developed almost entirely by the authorities of the Port of Los Angeles, who have been experimenting continuously for the past ten years in order to improve the process to the highest degree possible. The cost of impregnated concrete has been so reduced that it averages only from 25 to 40 per cent more than untreated concrete of the same quality, depending on the size of the units. Although no piles have been in service for more than about seven years, it is confidently believed that the process as now used will increase the life of plain concrete in and near the tidal range of sea water by several fold. Los Angeles Harbor has installed impregnated concrete piles in some 6,000 lin. ft. of waterfront structures and has under contract sheet piling for an earth-filled mole. Public port authorities and private interests at the ports of San Diego and Richmond, Calif., have used the process; and the authorities of the ports of Seattle, Wash., and Vancouver, B.C., are now considering its use.

ECONOMIC ADVANTAGES OF IMPREGNATED CONCRETE PILES

In the year 1915 very carefully manufactured concrete piles were driven in Municipal Pier No. 1, berths 56 to 60. These piles were precast, of a dense concrete mixture—proportioned with 1 part of cement to $1^1/_2$ parts of sand and 3 parts of gravel—and were unquestionably as strong and dense a precast pile as the average that could be manufactured today. Each pile was inspected by a diver following installation, and in case of fracture the pile was replaced. Some of the piles were painted with two heavy coats of one of the best waterproofing paints and a percentage of them contained waterproofing compounds as admixtures for experimental purposes.

Neither the painting, the admixtures, nor the oil residue that collects on piling at Los Angeles Harbor, had any effect in retarding the progress of deterioration. The painted piles as well as those containing admixtures seemed to deteriorate as rapidly as the plain ones. A very large percentage of the bearing piles began to show deterioration at the age of approximately 10 years, and the disintegration proceeded much more rapidly thereafter, so that at an average age of 12 years it had reached such an extent that the steel was exposed in a great many places within and adjacent to the tidal range, with attendant corrosion, causing spalling of the concrete.



PLANT FOR THE IMPREGNATION OF CONCRETE
Pressure Chamber in Foreground; Drying Kiln in Background; Small Experimental Retort, in Insert

In 1927 the piles were repaired by removing all damaged or deteriorated concrete and cutting slight excavations into the sound concrete to provide an anchorage for new work. The reinforcing steel was scaled and all rust removed by a sandblasting machine. The areas destroyed were then built up with gunite by means of a cement gun, so that the outer surface of the repaired or patched sections extended about $1/2$ in. beyond the original surfaces of the piles. The bond obtained, while the best it was possible to get, was nevertheless much poorer than that in the original poured piles, and deterioration in the renewed areas may be expected to proceed at an even more rapid rate than in the original piles. Moreover, additional areas of the original piling, not repaired at this time, may be expected to fail in the near future.

REPAIR WORK COSTLY

Repair work on some 320 piles cost an average of $21 per pile—an amount which could not be reduced appreciably at this time. The current price for manufacturing untreated concrete bearing piles at Los Angeles Harbor, with two applications of emulsified asphalt protective coating on their upper or most vulnerable sections, is $1.91 per lin. ft. The corresponding price for asphalt-impregnated bearing piles is $2.69 per lin. ft., representing an additional cost of 41 per cent. It is anticipated that this difference in cost will be steadily reduced.

The present worth of the total sums required over a period of 50 years for the repair of untreated piling, plus the amount required for complete replacement of the piles at the end of that period, is approximately $0.77 per lin. ft. This is considering that the piles have an average length of 48 ft.; are repaired at ten-year intervals at a cost of $20 per pile; and that interest is compounded annually at 5 per cent.

If to this $0.77 is added $1.91, the original cost of the untreated piles, the total sum is $2.68 per lin. ft., which is almost exactly equal to the present cost of impregnated piles. It is conservatively estimated that a well constructed impregnated pile is practically permanent, or at least will serve until the structure of which it is a part becomes obsolete—in any event for 75 years or more.

Such a comparison is not complete, however, since it does not take into consideration the repair of the second installation of untreated piles; the extremely high labor and equipment costs of pulling the old piles and driving the new ones; or the damages to buildings and wharf decks and the tying up of traffic over the structures—all factors incident to the replacement of the deteriorated piling. These factors combine to favor considerably the impregnated and more permanent piles.

PRESENT LIMITATIONS OF IMPREGNATION METHOD

To date, the impregnation method of waterproofing concrete has been utilized primarily for precast units sufficiently small to place in the impregnation chamber, dry kiln, and cooling chamber. These units, together with such installations as boilers, pumps, and piping, constitute a plant costing in the neighborhood of $75,000. The plant used for this work at Los Angeles Harbor has a treating cylinder which will accommodate piles having a maximum length of 82 ft. The cylinder is approximately 8 ft. in diameter and may be likened to the retorts used for treating timber products.

Bearing piles, sheet piles, and waling pieces for bulkheads and similar structures have been successfully treated at an increase of from 30 to 45 per cent over the total cost per cubic yard of the concrete. Some thought has been given to extending the impregnation process to make it applicable to concrete sea walls, bulkhead walls, concrete caisson-type breakwaters, and similar structures which are subjected to contact with sea water or spray. The method suggested, but not yet perfected or in use, is to precast and impregnate concrete slabs, which would then be utilized as exterior forms into which the concrete of the main structure would be poured. The slabs would be keyed to the surface of the concrete in such a way that they would remain as a permanent means of waterproofing the structure.

Byzantine Aqueduct Still in Use

Old Water Supply System of Constantinople

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DURING the past three years, while serving as Associate Professor of Civil Engineering at Robert College, Constantinople (now designated Istanbul by the Turkish government) Professor Smith made use of the opportunity to examine the ancient water supply system which still serves the city. This was probably built in the second century to bring drinking water by gravity to Byzantium, now a part of Istanbul. His description of the dams, conduits, aqueducts, tunnels, and measuring devices has wide interest. The great aqueduct of Justinian, a photograph of which is carried on the cover of this issue, is of particular importance because of its beautiful lines, its excellent state of preservation, and the evidence it presents of having been designed to resist earthquakes, which were prevalent in that section at the time of its construction. The tunnels, conduits, and aqueducts have a peculiar water-carrying section, so shaped as to accommodate a workman standing erect.

AMONG the remains from the Golden Age of Byzantine construction in Constantinople, of which the mosque of St. Sophia is the most famous, none is so extensive nor in a better state of preservation than one of the old water supply systems, which had its beginnings before Constantinople was made the capitol of the Eastern Roman Empire and possibly before the dawn of the Christian era. The reason for the apparent lack of general information concerning most of this elaborate system for the supply, conveyance, and storage of water, lies probably in the fact that it is spread over a large area and lies chiefly outside the old city walls. It is interesting to note that Justinian I, the Great, builder of St. Sophia, who ruled from 527 to 565 A.D., also took a very prominent part in the improvement of this water supply system.

According to Strzygowski and Forchheimer, in *Die Byzantinischen Wasserbehälter von Konstantinople*, this system was first constructed by the direction of Emperor Hadrian, who ruled from 117 to 138 A.D. It was repaired and extended under Justinian I, and again under Emperor Andronicus Comnenus (1183 to 1185 A.D.).

Since the time of its original construction, it has undergone many vicissitudes. Parts have probably been completely destroyed and many additions have been made, aside from normal repairs and replacements. Since the Moslem religion requires a liberal use of running water in the performance of its rites, the Turks have maintained the system quite carefully. Parts of it were abandoned or left to decay only as new supplies were made available. At present, plans for another restoration are in progress.

Originally this water supply system must have called for as careful planning and required as great ingenuity in construction as the Church of St. Sophia. As it is found today, it consists of four main parts: a series of developed springs; diversion and retaining dams for the collection and storage of the water; long lines of masonry aqueduct; and storage reservoirs within the old city walls. The masonry conduits follow the grade contour along the hillsides. Occasionally valleys are bridged and at four places hills are pierced by tunnels ranging in length up to three-fourths of a mile. This ancient system is the one shown by the heavy line on the map, Fig. 1.

The old city of Byzantium was situated at the eastern end of the peninsula that is bounded on the north by the Golden Horn, on the east and south by the Sea of Marmara, and on the west by the mainland. Some of the natural factors that worked for easy defense of the city and which probably influenced Emperor Constantine I,

THE GRAVITY DAM AT TOPUZ BENDI
165 Ft. Long and 23 Ft. High

STORAGE RESERVOIR, AIVAT BENDI, ON THE AIVAT DERESI
200 Ft. Long, with Broken Center Line

the Great (306 to 337 A.D.), to select this site for the capitol of his empire, make the securing of an adequate water supply difficult. Because of the steepness of the slopes, precipitation runs off rapidly so that little seeps into the ground. This lack of a supply of groundwater is aggravated by the fact that summer rainfall in Constantinople is ordinarily rather scanty, and such rains as occur are usually torrential. Hence, from early times, the residents have had to go beyond the limits of the city for their water supply. Before the building of this system, their needs were probably met by deep wells and by the collection of roof water, both of which means still find limited use today.

Two small streams, Kiathane Deresi and Ali Bey Deresi, flow into the extreme upper end of the Golden Horn, supplying the only considerable quantities of fresh water that this estuary receives. These streams have their sources in a range of high hills, an extension of the Balkan Range, which rise abruptly from the Black Sea and turn most of the run-off from European Turkey toward the south rather than toward the Black Sea. It was at the headwaters of Kiathane Deresi, the more easterly of these two streams, well into the Forest of Belgrade, that the Byzantines developed one of their major sources of water supply.

As this system is found today, it may be conveniently divided into three parts: works for the collection and impounding of water; a system of masonry conduits for its conveyance to the city walls; and a system of reservoirs, conduits, fountains, and other structures for its storage and distribution within the city. This article is primarily concerned with the first two of these.

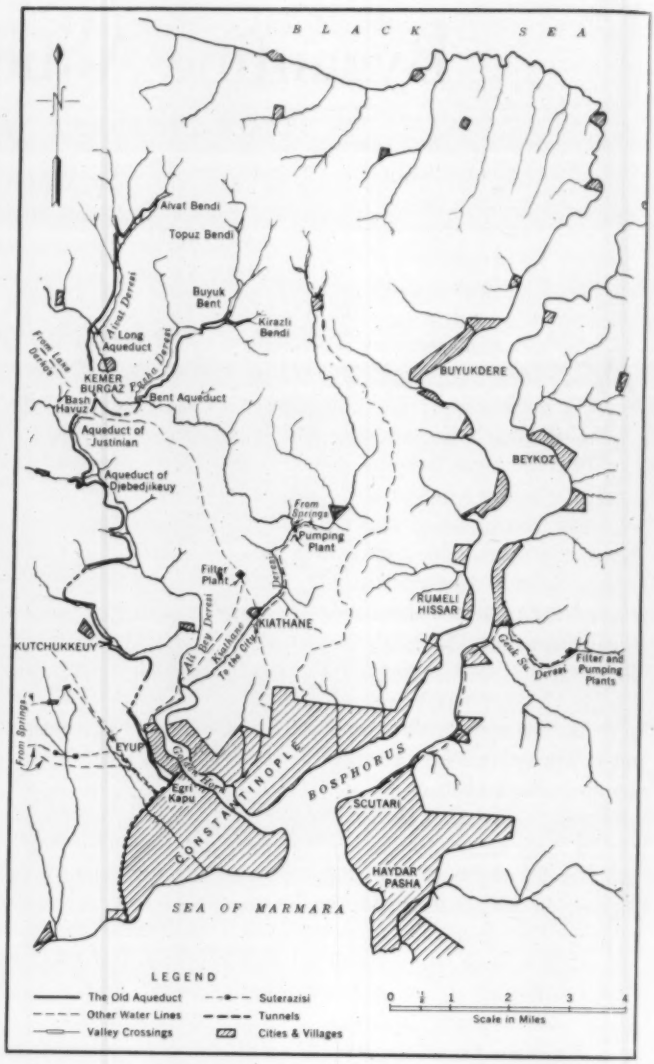
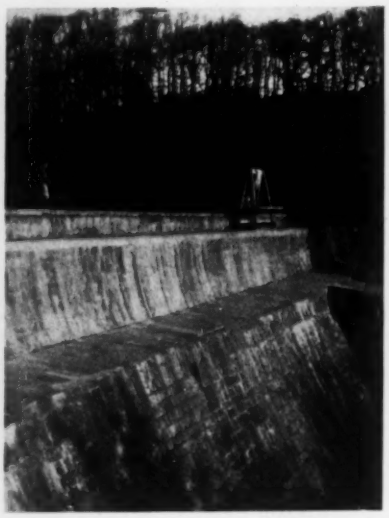


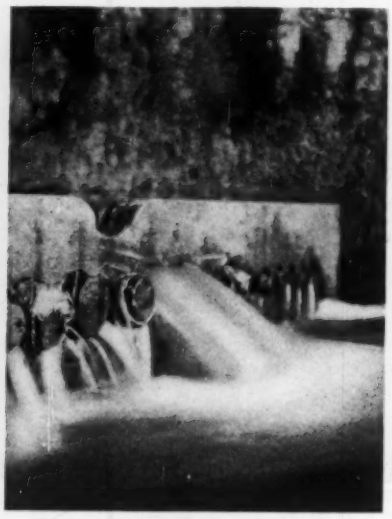
FIG. 1. ANCIENT AQUEDUCTS SERVING CONSTANTINOPLE With Locations of Modern Water Lines and Filters

ANCIENT DIVERSION DAMS AND STORAGE RESERVOIRS

The works for the collection and impounding of water, as they now exist, comprise three masonry dams, which form impounding reservoirs, one masonry diversion dam, and a number of developed springs, aside from several other diversion dams that are now out of use. The present structures, though they may rest on the sites of Byzantine diversion dams, appear to be thoroughly Turkish in construction. While there is no positive evidence to that effect, it seems probable that the Byzantines did not use high storage but only small diversion dams. As they relied upon storage within the city walls, there seems to have been little need for impounding reservoirs at the sources.

On the headwaters of the branch of Kiathane Deresi called Pasha Deresi is a group of three reservoirs that form a collection unit for one branch of the aqueduct. The largest of these is known as Buyuk Bent, the Great Reservoir. If the water were at spillway level, the lake formed would be about a mile long, with a maximum depth of about 40 ft. and a capacity of about 500 acre-ft. In spite of extensive recent repairs, the dam leaks considerably—through the masonry structure rather than under or around it. When the reservoir was full in 1891 streams the size of a man's arm leaked through. The leakage is as great today with the water level 10 ft. below the crest.

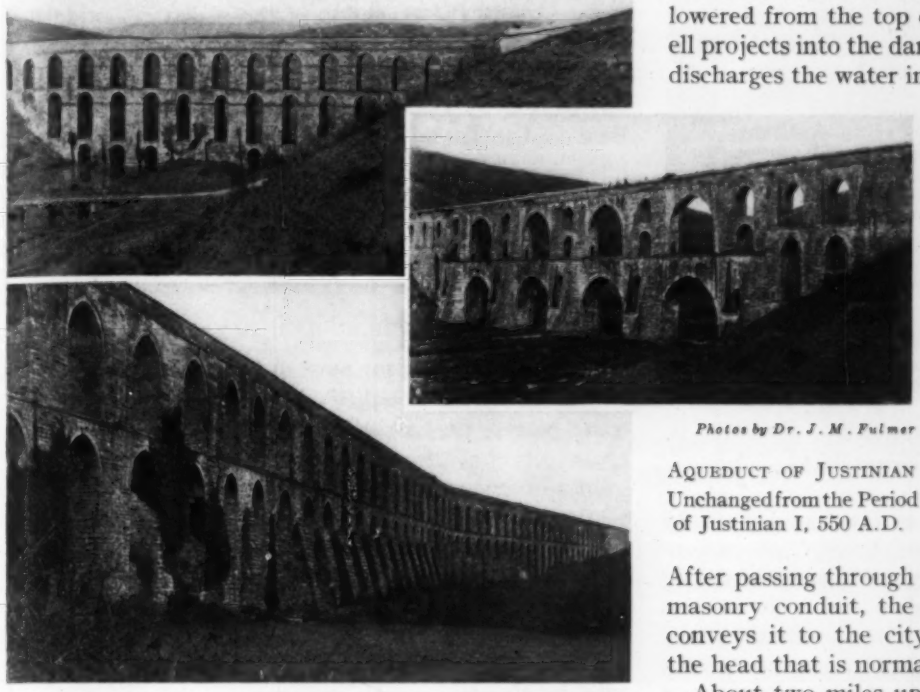




BUYUK BENT—DAM AND WATER MEASURING SYSTEM

The dam is of the massive gravity type with a maximum section 41 ft. high and 33 ft. wide at the base. It rests on bedrock, which is near the surface over most of this highland. It is probably built of rubble masonry,

but it is faced both upstream and down with roughly squared limestone. Its length is about 250 ft. At each end is a spillway, quite recent in construction but none the less interesting. The older spillway is 5 ft. long,



Photos by Dr. J. M. Fulmer

AQUEDUCT OF JUSTINIAN
Unchanged from the Period of Justinian I, 550 A.D.

ABOVE: THE BENT AQUEDUCT, NEAR KEMER BURGAZ
BELOW: DOWNSTREAM FACE OF LONG AQUEDUCT
Length 2,325 Ft.; Slope 7½ Ft. per Mile

measured along the center line of the dam, and the other is 15 ft. However, the spillway crest has a length of about 90 ft., obtained by extending the spillway upstream perpendicular to the center line of the dam and by means of a curve, extending it to the shore line. The crest edge is rounded on a radius of a few inches and discharges without abrupt fall into an inclined masonry channel which has at intervals basins that act as energy dissipaters, from which the water overflows and continues its course. The channel runs along the bluff line with a slope of one on five or six, to a point about 200 ft. downstream from the dam, where it discharges into the stream channel with little kinetic energy.

The means of drawing the water from the reservoir is quite unlike those utilized in the United States. On the upstream face of the dam there are two or three iron ells at different elevations. One leg of each is pointed upward and over it is fitted a cone which may be raised or lowered from the top of the dam. The other leg of the ell projects into the dam and connects with a passage that discharges the water into a masonry trough at the downstream face. There is a series of holes in one of the trough faces which may be plugged or opened as desired by the caretaker in charge. The quantity of water is controlled by adjusting the cone on the upstream side so that the water in the trough maintains a certain level with the desired number of holes open. The passage that conducted the water to the trough has now been replaced by a more modern cast-iron pipe with a gate valve. After passing through the trough the water falls into a masonry conduit, the beginning of the long line that conveys it to the city. No attempt is made to utilize the head that is normally available at the reservoir.

About two miles upstream from Buyuk Bent, on the main stream, is a second large reservoir called Topuz Bendi, Fig. 1. This reservoir is considerably smaller, due partly to the greater slopes that are characteristic of this section, and partly to the height of the dam, which is only 23 ft. This dam is a buttressed gravity section about 165 ft. long, founded on rock, with additional earth-fill sections, of 20 ft. at one end and 30 ft. at the other. With its small spillway, it would seem that this dam would be frequently overtopped. No masonry conduit carries the water from this reservoir to the one below, although an outlet device similar to the one previously described is provided.

The third structure of this group is a low diversion

DIVERSION DAM AND INTAKE BASIN AT KIRAZLI BENDI
The Intake Basin in the Foreground Is of the Type Called Havuz

JUNCTION CHAMBER—BASH HAVUZ, OR HEAD BASIN
Interior Diameter 26 Ft.; Depth 35 Ft.

dam called Kirazli Bendi, located about a half mile east of Buyuk Bent on a small branch of Pasha Deresi. At normal stages the outflow here includes the entire stream flow, although its rate may be regulated by means of a

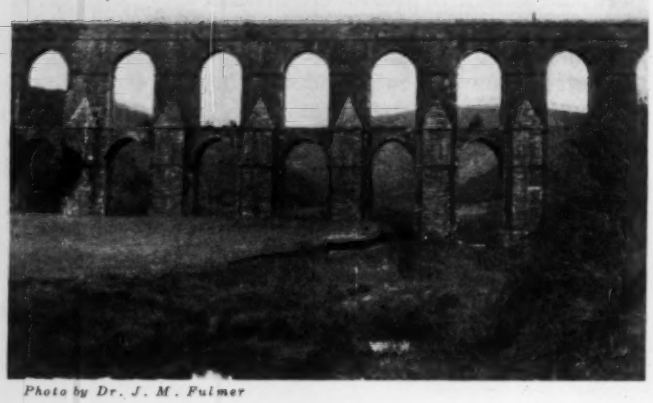


Photo by Dr. J. M. Fulmer

AQUEDUCT OF DJEBEDJIKEUY
Length 527 Ft., Maximum Height 109 Ft.

series of orifices in a marble slab set into the wall at the end of the dam. The water flows directly into a conduit which empties into a *havuz*, or basin, which in turn discharges into the masonry flow line. The present structure, though probably Turkish, is apparently of the same type that the Byzantines used to divert streams into their conduits. It is held together with clamps of iron leaded into holes in the stones, and with mortar, a method used on many structures in this vicinity.

Northwest of the group of reservoirs just described, farther in the Forest of Belgrade, on the tributary to Kiathane Deresi called Aivat Deresi, is a fourth dam, the reservoir of which is called Aivat Bendi. This reservoir is the second largest in this system. It furnishes the main supply for the other main branch of the conduit, although it has less than half the capacity of Buyuk Bent when the water is at spillway crest. The dam is of the gravity type with a broken center line, which makes it appear to arch upstream. Its length is about 200 ft. The spillway, which has a crest only 3 ft. long, makes a right-angle turn as soon as it is through the dam and discharges its water onto the rocky slope at the base of the dam. The dam is faced with marble over much of its surface. The outlet structure is similar to that at Buyuk Bent.

SPRINGS DEVELOPED TO AUGMENT FLOW

Springs augment the supply of water at numerous points along the flow line. These are developed by means of small, unglazed pipes, probably with open joints, or by means of galleries, both of which generally conduct the water directly to the conduit, although in some instances the flow from several springs is brought together before the water is conducted to the main stream. These springs are especially numerous nearer the city, in the valleys of Kutchukkeuy Deresi and other tributaries to Ali Bey Deresi. Instead of having enlarged bell ends, these handmade tile pipes have constricted spigot ends. They are usually less than 8 in. in diameter, about a foot long, and a little over an inch thick. They are used to convey water with pressures up to 25 lb. per sq. in. A jointing material composed of lime, olive oil, and soft fiber is used.

The conduits follow very circuitous routes to the city; in this regard the main line is worse than either of the branches. The map fails to show fully the irregularities of alignment. Every small declivity of this rugged country, with the exception of those that are bridged, is traced out by the very flat grade contour so that the length is estimated to be about half again as long as the line shown. Whereas the air-line distance from Buyuk Bent to the Taxim of Egri Kapu—the terminus of the joint line—is almost exactly 10 miles, the route along the flow line is estimated to be 27 miles. The ratio of these distances is approximately the same as that for the old Roman aqueduct near Nimes, France, of which Pont du Gard is a part.

LINED CONDUIT LARGE ENOUGH TO FACILITATE REPAIRS

The material used for most of the conduit is limestone, which in varying quality abounds in this region. In some places, partial brick construction is found. The cross section of the conduit varies considerably; extreme values of my measurements are shown in Fig. 2. The section was made large enough so that the interior could be periodically inspected and repaired. Overflows are provided at several points, which indicate that it was not planned to have the section flow full. The interior finish of cement plaster is carried to a point slightly above these outlets. To facilitate repair work, manholes were constructed at intervals, some being about a hundred feet apart and others several hundred feet. These structures vary from an irregular hole in the top of the conduit to a square, shaft-like structure extending three or four feet above ground. Much of the line can still be easily followed; the disturbing influences of centuries have not obliterated the flattened areas on the hill slopes caused by the construction of the conduits.

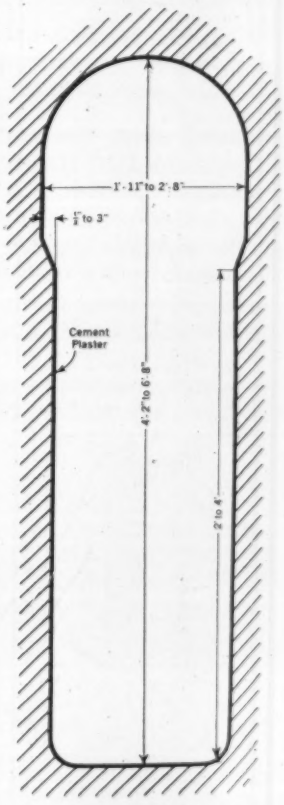


FIG. 2. TYPICAL SECTION OF CONDUIT
The Greater Widths Go with the Lesser Height and Vice Versa

MANY VALLEYS CROSSED BY AQUEDUCTS

On this system, no less than 40 valleys are bridged by structures consisting of one or more arches. Most of these are small, of from one to six arches. Several are somewhat larger, but only four require special mention. The Bent Aqueduct, which is called Egri Kemer (the Crooked Aqueduct) by the Turks, derives its name from the alignment of its plan.

Authorities disagree as to the date of its construction, though there seems to be general agreement that the original aqueduct on this site must have been as old as the system as a whole. The present structure is probably Turkish, incorporating the remains of its Byzantine predecessor. The material used throughout is limestone bound together with a kind of lime mortar and clamps of iron. It is of ashlar masonry with the exception of the first 350 ft. from the upstream end. There are no arches in this part, which is laid up of rubble masonry.

Galleries run lengthwise of the aqueduct at the floor level of both the upper and the middle tiers of arches, from points at which the floor levels are at ground level. Presumably, these galleries were built to facilitate construction. It would appear that the economical use of masonry might require the crooked alignment used, because the aqueduct follows a tongue of land nearly parallel to the valley before the crossing is effected at a narrower point. The Bent Aqueduct is 1,358 ft. long and has a fall of 1.1 ft. in this distance.

The Long Aqueduct derives its name from the fact that it is the longest of the valley crossings in this locality. Its indifferent planning and careless construction make it the least interesting of the four major aqueducts. Records indicate that it was erected during the reign of Sultan Suleyman I, the Magnificent, in the sixteenth century. Possibly it also rests on the site of an earlier structure but this is by no means certain. Other supplies could have been developed without crossing Kiathane Deresi at that point. The center line is somewhat broken and curved, the maximum angle of deflection being 29 deg. 35 min. Its extreme length is 2,325 ft., of which over 1,500 ft. is supported by arches. There are 50 arches in the upper tier, and originally

TAXIM OR WATER DIVIDER AT EGRI KAPU
At the Entrance Gate of Ancient Byzantium

there were 48 in the lower tier, but several of these near the north end were closed up to strengthen a failing section. In the lower tier, the span width varies from 14 to 17½ ft., and the longitudinal pier width from 9½ to 15 ft. The transverse pier width at the point of maximum height is 20 ft. The maximum height of the structure is 90 ft. and its top width varies from 7½ to 10 ft. There is no gallery through the piers, lengthwise of the aqueduct. Except for the ends and the repair work toward the north end, the masonry is ashlar.

The most interesting of these structures from both the architectural and engineering standpoints is the one

CISTERN OF ASPAR, NOW A FOOTBALL FIELD
One of 40 Storage Reservoirs Inside the Walls of Constantinople

known as the Aqueduct of Justinian, which the Turks call Muallak Kemer, the Aqueduct of the Hanging Arches. Most authorities agree that this, like the Mosque of Saint Sophia, has come to us almost unchanged from the period of Justinian I, the Great, although it has been repaired from time to time by various of the Byzantine emperors, and later by the sultans. Surely, it is the product of the most highly developed era of construction in Constantinople, judging only from the careful planning on which its architecture is based. Here, the builders diverged from the use of pure horizontal and vertical lines and the true semicircular arch found in the Roman aqueducts and buildings of earlier periods. Architecturally this marks a great advance, but from the engineering point of view it is even more important.

During the reign of Justinian I, Constantinople was shaken by a series of very severe earthquakes, one of which threw down the dome of the newly erected Church of St. Sophia. In view of this fact, it is to be supposed that the builders of the aqueduct, which was erected during the latter part of Justinian's reign, planned to make it earthquake resisting and thus brought into use the inclined lines and surfaces that dominate in this structure.

That these builders had some knowledge of at least the practical nature of arch action and lines of pressure seems evident from the fact that the upper of the main arches are of smaller span than the lower. The builders apparently realized that if one of the major arches were completely destroyed, the line of thrust of the adjacent upper arch would still fall within the foundation of the pier, thereby lessening the likelihood of further failure. To make sure that the line of pressure would fall within the area of the foundation, the pier dimension longitudinal to the aqueduct was increased. The pier, in turn, was lightened by incorporating arches in it. The stability of the structure through the ages has been a tribute to the wisdom of its builders. Its general lightness is very evident in the accompanying pictures, especially

when compared with the clumsy aqueducts that are common in and near Rome. It compares well in this respect with Pont du Gard near Nimes.

Possibly, also, the builders understood something of the hydraulic advantages to be gained by placing a few relatively large piers, rather than many smaller ones, in the way of a river in flood. It is of interest to note that starlings were used on the upstream faces of the piers. They are triangular in plan and have vertical, slightly rounded noses.

At the floor level of the upper tier of arches, there is a gallery that extends through the three main central piers. It is reached by means of stairways that run downward from this level through the outer main piers to the floor level of the adjacent arches. These arches connect with smaller arches at ground level on the hill slope by means of short galleries. After serving for construction purposes, this passage was not closed up, and at the present time it serves as a footbridge for the shepherds of this sparsely settled region.

The aqueduct is constructed of large blocks of limestone, which in some cases are nearly 2 ft. thick. They are roughly cut, but have drafted margins, with the exception of the arch stones, which are dressed. The joints are thin and are made of lime mortar. A few iron clamps are in evidence.

The structure known to the English-speaking people of Constantinople as the Aqueduct of Djebedjikeuy is less elaborate in its construction than any of those already mentioned. However, its sturdy, regular construction makes it worthy of note. Its length is 527 ft. and its height above the valley floor is 89 ft., but it is 109 ft. above the deepest point in the stream at the point of crossing. It is the only one of the four mentioned whose center line is straight.

Aside from some weathering the aqueduct is in an excellent state of preservation. It is quite obvious that it is not as old as the Aqueduct of Justinian and is probably of Turkish construction, although it necessarily had a Byzantine predecessor.

GRADE CONTOUR AQUEDUCT ALIGNMENT

Southward from the Aqueduct of Djebedjikeuy, the aqueduct line follows along the hills that rise from the flood plane of Ali Bey Deresi, crossing many valleys with an arch or two. At a point where Ali Bey Deresi makes a sharp turn to the eastward, the line follows the narrow valley of a tributary, which it finally crosses. Here it runs into a steep valley and disappears into a tunnel. About a half mile further on, in a fertile, alluvial valley, the conduit is again near the surface. This tunnel connects the valleys of two tributaries of Ali Bey Deresi.

The aqueduct follows the second tributary for two or three miles and finally goes again into a tunnel, crossing to a valley that drains into the Golden Horn at Eyup, saving several miles by avoiding the grade contour.

Probably all the tunnels are as old as the system as a whole. The methods that were used in driving them are not certain, but were probably those conjectured by James F. Case, M. Am. Soc. C.E., in his paper on "The Ancient Roman Aqueduct at Athens," in TRANSACTIONS, Vol. 91, page 281, inasmuch as they date from the same period.

As the use of running water is necessary in the Moslem religion, it is quite natural that the points of development and other controlling sections should be given special attention. Thus, near the dams and at points of junction, special structures are generally to be found. These are in the form of basins, usually circular in plan, such as the one at Kirazli Bendi which is illustrated, or that called Bash Havuz (Head Basin). An exception to this is Tchift Havuz (the Twin Basin), near Buyuk Bent. The purpose of these seems not have been practical to any great degree, as the water flowed in from one direction and out in another.

At points from which water is drawn from the stream or at which the stream as a whole is divided, another special type of structure, called a *taxim* (divider) is used. This consists of a small stone house into which the aqueduct line is built. Inside is a stone trough or small basin into which the water flows. In one or more of the walls are holes through which the water flows into two or more conduits. In this way, the stream can be divided in any ratio desired.

The quantity of water which is conveyed to the city by this aqueduct varies greatly at the present time. It is not constant with respect to time, and due to leakiness, the rate of flow decreases as the distance from the source increases. At the Aqueduct of Djebedjikeuy I have observed the depth to vary from 0.4 ft. to 2.5 ft., which, on the basis of estimated velocities, means a variation in discharge from 0.8 to 9.7 sec-ft. According to Andreossy in *Constantinople et le Boshpore de Thrace*, published in 1828, the normal discharge at Egri Kapu was 134 lule. Taking the estimate of Strzygowski and Forchheimer for a lule as 0.01 sec-ft., the usual quantity supplied by this system when it was in good condition was about 870,000 gal. per day.

Aside from the supply system just described, Constantinople today receives water from several other sources, most of which are shown in Fig. 1, but which cannot be described here.

The distribution of the water that is brought to the city at the gate of Egri Kapu has not been traced, but according to available sources, one of the conduits leads toward the quarter of the Mosque of Saint Sophia and the other toward the Yedi Kule quarter on the Sea of Marmara. Other *taxims* divide these streams at various points. Within the city, numerous underground reservoirs have been found, some large and some small. Over 40 have been investigated and quite definitely identified with various periods of Byzantine history.

Beside the covered reservoirs, three large open reservoirs are located within the city walls and one large one a short distance outside. The largest of these is that called the Cistern of Mocius. Its inside dimensions are about 480 by 560 ft. and at the present day it is depressed about 35 ft. below the surrounding ground. Next in size is the Cistern of Bonus, said to have been built in 627 in honor of the patrician, Bonus, for his victories over the Avars and Persians. It is about 500 ft. square and is still depressed about 25 ft. The third open reservoir within the walls is called the Cistern of Aspar. It is about 280 ft. wide and 800 ft. long and is still about 25 ft. deep. Its thick masonry walls are of alternate layers of brick and stone, similar to those of the Cistern of Bonus. Today its floor is used for a football field and for several market gardens.

Asphaltic Emulsions for Economical Highways

New Treatment of an Old Material Results in Its Wide and Successful Application

By C. L. McKesson

Member American Society of Civil Engineers

Director, Engineering and Research, American Bitumuls Company

EVEN the oldest engineering processes and the commonest materials are constantly undergoing improvement. When new uses affect such a tremendous and far flung industry as road building, they should be brought to every engineer's attention. Asphalts have been long and widely used, and so have emulsions made by treating ordinary asphaltic oils so that they will be held suspended as minute particles in water. This dilution gives a convenient and economical means of manipulation and results in a satisfactory pavement when the binder hardens by evaporation of the water. Most of the methods here described by Mr. McKesson have been developed since the War. Used first on the Pacific Coast, some of them only a few years ago, these methods have since spread throughout the country. Their popularity in terms of the extent of their use is increasing rapidly.

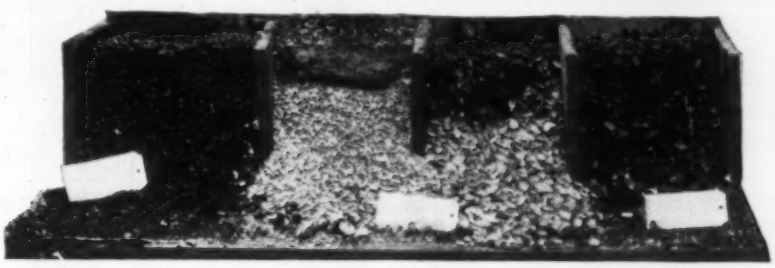
IT is an old adage that "Necessity is the mother of invention." The present extensive use of emulsified asphalts throughout the world is probably a direct result of the destruction of European macadamized highways by the terrifically heavy motor transport traffic made necessary by warfare. The close of the War found the highways of France and Germany badly worn, while funds for reconstruction were pitifully meager. During the period from 1914 to 1919, traffic had changed from iron-tired, slow moving vehicles to fast automobiles on pneumatic and hard rubber tires. As foundations were everywhere adequate, bituminous treatments were the obvious solution to the reconstruction problem.

European engineers, as a class, have been trained in frugality. In Europe the engineer is indeed "a man who can do with one dollar what a layman would do with two dollars." The idea of destroying macadam foundations and replacing them with a slab type of pavement, or of laying a heavy slab on top of an already adequate base, was so clearly unsound that it was promptly rejected.

Modern Type of Emulsified Asphalt—A War Development

In the United States heavy soap and clay emulsions had been manufactured for many years and extensively used on highways for certain types of pre-mixed maintenance work. Relatively quick-setting emulsions of low viscosity, capable of penetrating deeply into road metal, were developed more or less accidently during the War period.

After the War, factories were established at various points in Europe, and engineers quickly discovered the advantages of asphalt in this form. Its use has continued to increase rapidly throughout European countries, and in 1927 this very interesting construction material made its advent on the Pacific Coast. Its popularity grew in America as it had in Europe, so that at the present moment emulsified asphalt plants are situated in many of our principal cities, and the annual use reaches millions of gallons. Yet there are many engineers, including those specializing in highways, who are still unfamiliar with the modern development and application of this old material.



Penetration of Emulsified and Hot Asphalt Into Bins of Fine Screenings and Rock

Economical Road Material Needed in America

All nations have watched with great interest the tremendous era of highway development which, beginning in the United States about 15 years ago, has gradually increased until the expenditures for road building purposes in 1930 reached the colossal sum of $1,718,000,000. We Americans are apt to be satisfied with our progress, so it is a bit startling to discover that with all our activity and huge expenditures, we have today succeeded in paving only 3 per cent of our 3,000,000 miles of rural roads, and in surfacing with types of pavement classed by the Bureau of Public Roads as "intermediate," only 1 per cent more. Another 23 per cent are surfaced with gravel, macadam, sand, clay, and other so-called "low" types.

Of our entire road system, 73 per cent, or about 2,300,000 miles, is still plain earth road without any surfacing. It would appear that at our present rate of progress it may be two or three hundred years before the traffic of the country is entirely served with improved highways, provided we continue to build only the heavy and expensive types used in the earlier stages of our development.

Our 26,500,000 automobiles are now taxed, on an average, $35 per year for road building purposes, and it is not likely that great tax increases will be acceptable. In view of this situation it would seem that America should turn to light and economical types of construction, which will utilize existing road foundations to the utmost and will result in greatly increased mileage from present revenues.

It would be very fine to have the entire road system of America paved with wide, hard-surfaced concrete or bituminous pavements costing from $20,000 to $50,000 per mile, but such construction would be uneconomical and its cost would lie beyond any possible limits of funds now available or anticipated for the future. In order to be economically sound, a road should be of the least expensive type which will carry the traffic comfortably. The gage of economy in road construction is the cost per mile per year, which cost should include interest on the investment and a fund for reconstruction, whenever that is needed, together with a proper allowance for maintenance.

FIRST APPLICATION OF EMULSION ON FULL PENETRATION WORK
State Highway Near London, Ohio

When so analyzed, it will be found that standard so-called "high types" of pavement represent an annual cost of from $2,000 to $4,000 per mile. On the basis of the revenue available from all auto taxation, such a road can never be economically justified unless the traffic amounts to 1,000 vehicles per day or more throughout the entire year. On the other hand, light bituminous types of construction, including those on sound rock or gravel bases, represent an annual cost of from $400 to $2,000 per mile, and are economical, if properly designed, wherever traffic exceeds 200 vehicles per day.

TYPES OF ASPHALT EMULSIONS

It has been said that oil and water do not mix. This is incorrect, for emulsions of the type under discussion consist of petroleum asphalt broken up into almost infinitely small globules and carried in suspension in water. Technically, the asphalt is said to be in the "dispersed" phase and the aqueous, or water solution is the continuous phase. The microscopic particles of asphalt are prevented from coalescing by a reduced surface tension on those globules, and according to some scientists by reason of an adsorbed negative charge on the surface of each globule.

There are two distinct types of asphaltic emulsion, one known as a mixing emulsion, which is slow setting in character, and the other a quick-setting, penetrating product. Mixing emulsions have been on the market for many years and most engineers are familiar with them. Of necessity, they are slow setting, to permit time for the manipulation of the aggregate after the emulsion is added; and they are capable of being mixed with water and may be diluted if required. Mixing emulsions usually contain considerable amounts of stabilizing materials. Their breaking, setting, and coalescence are brought about largely by evaporation.

Penetrating emulsions, however, constitute a newer type—one which is entirely different in character. In order to penetrate properly, these emulsions must have a high degree of fluidity. The asphalt in the emulsion should remain uniformly suspended during a long period of storage, without sedimentation or coagulation, but should set quickly after the emulsion is applied to the stone on the road, in order to prevent possible damage from showers during construction. Such emulsions should have a very high degree of purity in order that after coalescence the coating on the stone may be only pure asphalt.

Penetration emulsions having quick-setting properties are manufactured without the use of soaps or other stabilizers, by processes developed during recent years. In one of these methods, previously formed quick-setting emulsion is used as an emulsifying agent for subsequent batches. Relatively pure quick-setting emulsions are also made with very low soap content by the use of colloidal mills, or other equipment capable of mechanically producing very fine dispersion. Californian, Mexican, and Venezuelan asphalts are commonly and satisfactorily used. Residues from oils having a paraffin or semi-paraffin base are not satisfactory for the manufacture of quick-setting emulsions.

GRADER USED TO SPREAD STONE COATING ON BASE
Armorcoat Construction, Highland Avenue, San Bernardino, Calif.

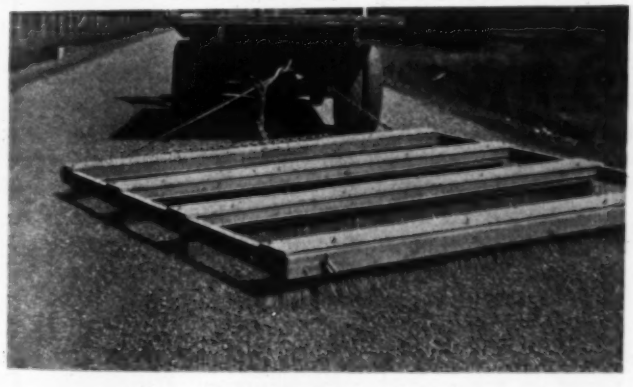
Emulsions of either the slow-setting or quick-setting type are ordinarily transported in tank cars and used at destination without heating or dilution. Penetration and road-mixing emulsions are readily applied cold with ordinary pressure distributors. For maintenance work, materials of either type are frequently furnished in iron drums.

PENETRATING QUALITIES

Tests have shown the remarkable penetrating properties of the quick-setting emulsions adapted to this

type of work, when applied cold to open boxes of stone screenings of uniform depth. An accompanying photograph shows the results of such a test. All four boxes were filled to a depth of 12 in., the two at the left with fine screenings of the same size, and the two at the right with the same grade of coarser stone. Emulsified asphalt applied cold to the two outside boxes penetrated thoroughly and uniformly through 12 in. of screenings, depositing an even coating throughout. But hot asphalt of the same quality penetrated less than one inch, when applied to the same fine screenings, in the second compartment from the left; and only 3 or 4 in. of the coarser stone in the third compartment. The stone was cold in all cases.

Repeated tests of this sort reveal the fundamental differences between the action of emulsified and hot asphalt. In emulsified asphalt pavement construction the voids between the coarse rock can be filled with fine particles and the entire mass penetrated with the emulsion, which produces a coating of asphalt on every particle throughout the pavement. However, by this method no sizable voids are filled with asphalt and consequently when the pavement is compacted by rolling or traffic there is no displacement or squeezing of asphalt to the surface, producing a slippery or sticky condition. In the test, the emulsion produced a coating of asphalt on the fine screenings equal to 3.8 per cent of the weight of the rock, whereas the fat carpet of hot



FINAL BROOMING OF THE SURFACE
Armorcoat Pavement

asphalt amounted to nearly 18 per cent. It is quite obvious that a road surface so constructed would bleed excessively when traffic pounded the stone particles together, and in hot weather.

PAVEMENTS SUIT VARIED CONDITIONS

Emulsified asphalt surfaces remain non-skid. They are constructed with less than one half the amount of asphalt used in hot penetration due to the fact that the voids are filled with small rock particles and the asphalt is present only as a coating. Because of the predominance of the rock particles and because there is no surplus of asphalt, such pavements are characterized by their permanent non-skid characteristics. To the automobilist bent on making speed, this property is of tremendous importance, and frequently prevents unnecessary loss of life.

DRAGGING AFTER FIRST APPLICATION OF EMULSION
Road-Mix Construction, Carroll County, Kentucky

One of the advantages of emulsified asphalt construction is that the pavement may be as thick or as thin as required. Pavements of 6 and 7-in. full penetration can be designed for heavy traffic over earth subgrades. Where there are good macadam foundations, or old pavements of sufficient strength to serve as a base, a bituminous penetration wearing surface 2 or 3 in. thick will serve. On secondary or lightly traveled roads, "retreads," "armorcoats," and "light wearing surfaces" (double-surface treatments) are constructed, varying from 2 in. to even $\frac{1}{2}$ in. in thickness.

FULL PENETRATION PAVEMENTS

Emulsified asphalt pavements of the macadam type are usually designated as "full penetration" pavements, to differentiate them from hot asphalt construction, in which complete penetration is prevented by the congealing of the hot asphalt. To construct a full penetration pavement, coarse crushed stone ranging in size from $1\frac{1}{2}$ in. minimum to $2\frac{1}{2}$ or 3 in. maximum, is distributed on the subgrade in sufficient quantity to produce, after compaction, the required thickness of the pavement, or of the course, if the surface is constructed in more than one layer. This material is trued up exactly like any standard macadam base, and the coarse rock is rolled until it is locked together.

At this point the method of construction departs radically from that used in hot penetration work. After the coarse stone is rolled, clean screenings or chips, varying in size from $\frac{1}{2}$ in. to 10-mesh, are distributed over the base stone in sufficient quantities to fill the voids within an inch of the top. These screenings are rolled and broomed to sift them into the base. The base is then ready for its first application of emulsified asphalt, which is applied in sufficient quantity to penetrate through the stone and the clean screenings.

Key stone, usually from 1 in. to 10-mesh in size, is then applied in sufficient quantity to fill the coarse base stone. After it has been properly distributed

by brooming, and rolled into place, the pavement is given its second application of emulsified asphalt. Any standard pressure distributor is suitable for this work.

After the second application, 1/4 in. to 10-mesh stone chips are applied in sufficient quantity to chink up the spaces remaining in the surface. A sealing coat is finally applied and covered with fine stone chips. Sometimes the sealing coat is divided and applied in two sections, the last followed by a light sanding with a very coarse sand or a fine pea gravel. It is important in this as in all other types of work to secure a waterproof pavement. By regulating the size of the stone chips, the texture of the surface may be varied to suit particular needs and the taste of the engineer.

THE FINAL RESULT—ROAD-MIX CONSTRUCTION AFTER THREE YEARS OF TRAFFIC
U.S. Route 40, California State Highway Near Towle, Placer County

The pavement thus produced has a high degree of stability, due to the thorough interlocking of the coarse rock and the fact that all voids are filled with asphalt-coated stone chips. The cost of this type is usually only about two thirds that of an equal thickness of any other standard type of asphaltic pavement.

ARMORCOAT CONSTRUCTION

Where traffic does not exceed 2,000 or 3,000 vehicles per day and where the foundation is adequate for this load, the emulsified asphalt armorcoat wearing surface has already demonstrated its economic value. This pavement may be built from 3/4 to 1 1/2 in. in thickness. It is in reality a machine-made penetration macadam.

For the construction of a 1-in. armorcoat, the surface of the roadway is swept to remove loose dust or gravel, or is given a preliminary application of emulsified primer (a light fluxed asphalt). If a primer is used it must be allowed to penetrate before the work is continued. The base is then given an application of from 1/8 to 1/4 gal. of emulsified asphalt per square yard and covered with about 50 lb. per sq. yd. of from 1/2 in. to 1 in. crushed stone, which can be spread directly from trucks and made uniform with a road grader. The stone is smoothed by brooming and bedded into the tack-coated base by rolling.

When this stone is smooth and uniform, it is given a second application of emulsified asphalt (from 1/4 to 3/8 gal. per sq. yd.) and immediately covered with about 20 lb. to the square yard of from 1/2 in. to 10-mesh screenings. The screenings can be spread by truck and smoothed by a broom drag used in conjunction with a roller. The third application of emulsified asphalt, of from 1/4 to 1/2 gal. per sq. yd., is then spread and is immediately covered with approximately 15 lb. of stone chips per square yard, preferably from 3/8 in. to 10-mesh. After this coating has been thoroughly broomed and rolled, the pavement is ready for traffic. Long broom drags are very helpful in producing a smooth and pleasing road surface.

This type of construction, being entirely mechanical, produces at low cost a surface of great smoothness, with the permanently non-skid texture which is characteristic of all emulsified asphalt construction. The cost of the work varies from $2,500 to $3,500 per mile.

SURFACES MIXED IN PLACE—"ROAD-MIX"

Another type of construction involves the mixing in place of emulsified asphalt with aggregate previously spread on the subgrade, or with that produced by scarifying the old surface. Sometimes a nominal amount of new material is added and the remainder obtained by scarifying. This type of work is usually called "road-mix" or sometimes "retread." Ordinarily the term "retread" is used when the aggregate to be treated is relatively coarse, and the term "road-mix" when it contains considerable amounts of fine stone chips and dust.

In a typical road-mix, using emulsion, the material to be treated is spread out on the roadway with blade graders and saturated with water, using not less than 1 gal. per sq. yd. of surface. Emulsified asphalt of the mixing type is then applied at the rate of about 1/2 gal. per sq. yd. of surface. The road is immediately dragged with spring-tooth harrows and disk cultivators and about 1 in. of the treated material is bladed into a windrow. The second application of emulsified asphalt is made, disked, and bladed into the windrow. In like manner the third application of emulsion is made to the remaining metal, and the partially mixed material is thoroughly blended by further blading. After the material has been thoroughly mixed, it is spread on the subgrade and rolled to a smooth surface.

It is customary to build half the roadway at one time in order to permit the passing of traffic. After the mixture is rolled into place, a sealing coat is applied, sometimes in one application and sometimes in two. This coat should consist of 1/2 gal. of emulsified asphalt covered by from 20 to 30 lb. of stone chips per square yard.

Surfaces constructed in this manner are exceedingly hard and closely resemble plant-mixed asphaltic concretes. The cost of such treatment for a 3-in. finished

thickness of road-mix, including emulsified asphalt and screenings for the sealing coat, ranges from $2,500 to $3,000 per mile, exclusive of the new road metal added to the mixture.

RETREAD WORK

Retread is usually constructed by spreading crushed stone, ranging from 1/2 to 1 1/2 in. or more in size, in sufficient quantities to produce the required thickness of pavement. Enough mixing emulsion to penetrate and coat the stone is then applied with a pressure distributor. The stone is bladed and scarified to expose fresh surfaces for subsequent coating and to uniformly distribute the material on the roadway. It is then rolled to a smooth surface, and key stone is spread in sufficient quantity to fill the surface voids.

Key stone is distributed by blading and with broom

FOR LIGHT WEARING SURFACES THOROUGH SWEEPING IS ESSENTIAL
Alameda County, California

drags, and thoroughly rolled. The surface then receives a second application of emulsified asphalt followed by a cover of fine screenings, which are again distributed by blading and brooming and thoroughly rolled. If a black-finish pavement is desired, a third application of emulsified asphalt may be made and allowed to harden for about 24 hours before the road is open to traffic.

LIGHT WEARING SURFACES

Given good foundations, the least expensive type of construction adapted to secondary roads is an emulsified asphalt light wearing surface. The first step in its construction is to thoroughly sweep the foundation, using a power broom, until all loose material is removed. The best results are obtained when this brooming is continued until the stone in the base stands out in a mosaic.

Quick-setting penetration emulsion to the amount of from 1/4 to 1/3 gal. per sq. yd. is then applied as a tack coat and immediately covered with 1/4 to 3/4-in screenings at the rate of from 20 to 27 lb. per sq. yd. of area. These coarse screenings are broomed to a uniform surface and rolled so that they bed into the emulsified asphalt tack coat. The surface is then given an additional application of from 1/3 to 1/2 gal. of emulsion per square yard and covered with stone chips or pea gravel, at the rate of from 12 to 15 lb. per sq. yd. The stone chips or pea gravel are broomed to insure uniformity and smooth surface and rolled until thoroughly compacted.

Surfaces of this type are economically sound on roads carrying traffic up to 1,000 vehicles per day, although they have been successfully used for considerably heavier traffic. The cost of a light wearing

PLEASING RESULTS OBTAINED WITH LIGHT WEARING SURFACE USING EMULSIFIED ASPHALT
After Three Years of Heavy Traffic, Alameda County, Calif.

surface of this type is extremely low, usually ranging from $1,500 to $2,000 per mile.

EMULSIONS OFFER VARIED POSSIBILITIES

It will be seen from the foregoing discussion that it is possible with asphalt emulsions to construct varied types of surfaces for any condition of base or volume of traffic, and in keeping with almost any required limitation of expenditure. It is entirely sound from an economic standpoint to construct a light wearing surface, the cheapest type, with the idea of giving a similar retreatment at intervals of from three to five years. By following this procedure the total annual cost of the road over a long period of years can be kept to a minimum figure, while traffic is continually provided with a smooth, dustless, and non-skid surface.

Of the types of construction mentioned, the heavier ones, first described, are adaptable to new construction. Should settlement or other weakness develop in the subgrade, the surface can be returned to its original contour readily and economically by treating with a retread surface, or with an armorcoat.

Use of emulsified asphalt results in lengthened construction seasons, because the wetting of the stone is not an obstacle, and the work under construction is not injured by adverse weather. It is preferable, however, as in all bituminous construction, to begin work early in the season in order that the finished pavement may have the benefit of compaction under traffic prior to the winter season. With proper care and reasonable protection from traffic in bad weather, amazing results can be obtained with emulsion construction under most unfavorable conditions.

Wards Island Sewage Treatment Plant Begun

Activated Sludge Process Selected for First Unit of New York's Sanitation Program

By GEORGE W. FULLER

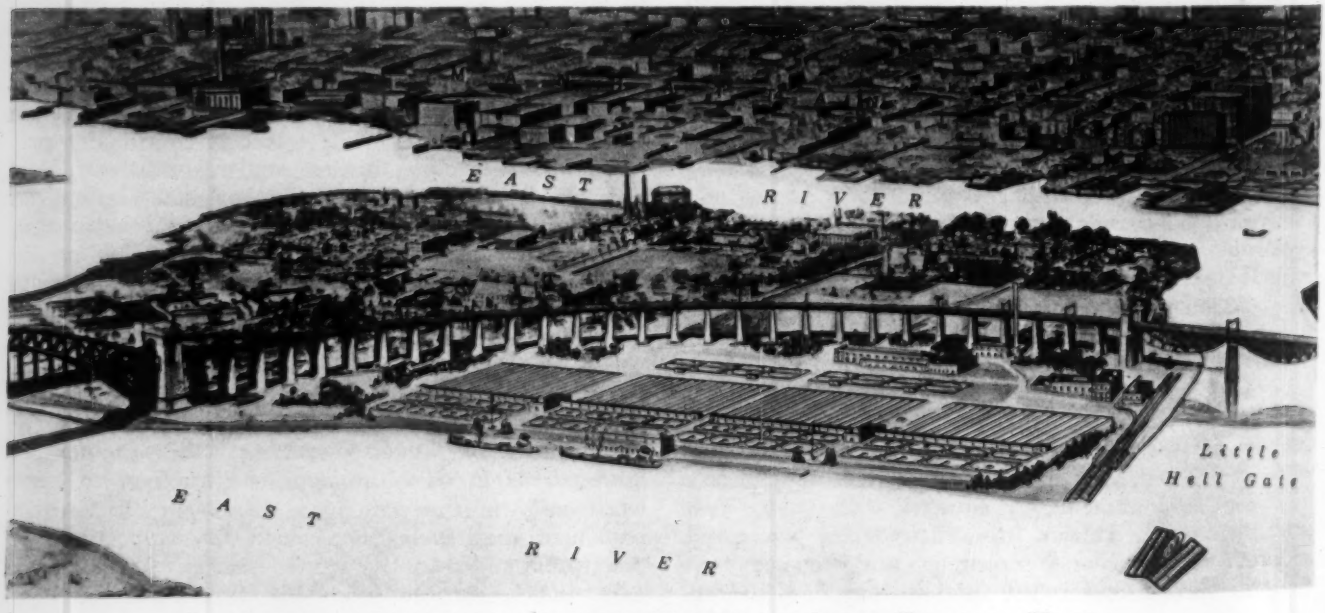
MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
FULLER AND MCCLINTOCK, ENGINEERS, NEW YORK

ON July 7, 1931, ground was broken for the construction of the Wards Island plant, which will be the largest activated sludge sewage disposal works in the world. It will treat a flow of 180 m.g.d. of sewage and serve a population of 1,350,000, nearly one-fifth that of greater New York. Many details of design which have been developed elsewhere and proved effective have been incorporated in the plans, to facilitate operation and reduce construction costs. No major departures from proven practice have been made. This $30,000,000 plant, with its collecting works, is the first part of a program calling for the ultimate purification of all the sewage entering New York Harbor. The volume of domestic and industrial waste and of spent water now entering the harbor approaches a billion and a half gallons daily. This paper was originally presented before a recent meeting of the Metropolitan Section of the Society.

MANHATTAN has been described as an island surrounded by sewage. This statement is rather extreme but it is a fact that the waters of New York Harbor and its branches receive the entire sewage flow from the Metropolitan District, which has a population of eight million. This flow consists of spent water supply together with street washings and household and industrial wastes removed by water carriage. The organic filth entering the local waterways is enormous. Its polluting influence is one of the penalties imposed on modern civilization as developed in large centers of population. Although the solving of a community's sewage problems is an important obligation from the standpoint of sanitation, it has generally been allowed to extend over a long period. Progress in this direction has been pitifully slow.

Treatment of the spent water supply of a community, with its burden of various organic wastes, has never been and never will be a branch of municipal housekeeping that is approached with enthusiasm by civic authorities. The problem relates to waste products from which there is no possibility of securing a substantial income such as can be gained from water works, and from transportation and other utilities. It is largely a matter of "what is out of sight is out of mind" so long as nuisances do not become too conspicuous in the opinion of a considerable percentage of the population. Appropriations for sewage treatment works are at the bottom of the list of expenditures receiving popular support. Notwithstanding modern legislation to promote sanitation, this type of expenditure ordinarily gives place to improvements in streets, schools, hospitals, parks, and many other municipal activities. It takes a surprisingly long time for public officials to remedy the conditions causing foul, black waterways unless the resulting nuisance affects the noses and eyes of a large number of people.

For years there has been a growing diminution in the oxygen content of the Harlem and upper East rivers, and a corresponding exaggeration of the unsightly and malodorous condition of those waters. Discussion of the subject by various state, municipal,



ARCHITECTS' CONCEPTION OF COMPLETED WARDS ISLAND SEWAGE TREATMENT WORKS
Hell Gate Arch at Extreme Left

and civic bodies did not bring about the solution of the problem. But when large real estate developments along the East River began to take an important part in municipal progress, the problem acquired a status more commensurate with its importance. In other words, personal comfort and commercial interest have become factors in the situation, thereby aiding materially the solution of the problem, which otherwise might have been still longer deferred.

State and municipal authorities have by no means closed their eyes to the gravity of this situation in New York. As long ago as 1887 the late Rudolph Hering, M. Am. Soc. C.E., reported to General Newton, Commissioner of Public Works, on remedial steps and advised that sewer outlets be extended from bulkhead to pierhead lines. More than a dozen years were required for the completion of this work. For over 25 years careful inquiries have been made by many commissions and boards to determine to what extent this large body of harbor water could be depended upon to purify the organic wastes coming from a large and rapidly growing population. Even this period was too short to get remedial works actually under construction.

WARDS ISLAND SITE SELECTED

It is nearly 20 years since the Metropolitan Sewerage Commission recommended Wards Island as an appropriate site for a sewage treatment plant. This island is located in the East River at its junction with the Harlem River and Long Island Sound, about opposite the north end of Central Park. Wards Island is owned by the city, but many years ago it was leased

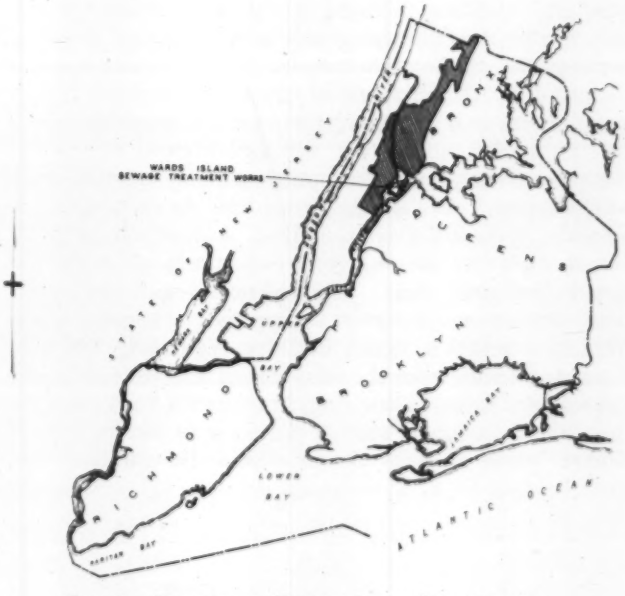


FIG. 1. TRIBUTARY DRAINAGE AS RELATED TO GREATER NEW YORK

to the state for the Manhattan State Hospital. It also bears the westerly abutment of the great Hell Gate arch of the New York Connecting Railroad, which crosses the island on a viaduct.

Shortly after the Armistice, efforts were begun to secure by legislation the release to the city of the 50 acres comprising the northeast section of Wards Island, and located north of the railroad bridge. This section of the island was used largely as a truck garden for the hospital. In the spring of 1927 legislation was effected for the release of this site by the state.

This plant will take care of sewage from two sections, one in Manhattan and one in the Bronx. The area in Manhattan comprises 2,720 acres now draining into the East and Harlem rivers, north of 74th Street and south of the Polo Grounds at 158th Street, as shown in

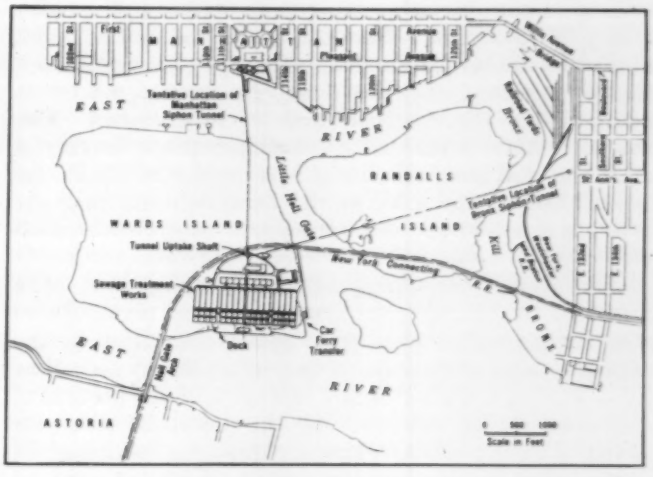


FIG. 2. LOCATION OF WARDS ISLAND PLANT AND SIPHON TUNNELS

Fig. 1. In the Bronx, the tributary area of 4,700 acres extends from West 192nd Street on the Harlem River to East 149th Street on the East River, and from the grit chamber near St. Ann's Avenue, to Jerome Avenue. In this total area of 7,420 acres to be served by the first construction program, it is estimated that within the next dozen years the population will reach 1,350,000, and the average sewage flow, 180 m.g.d.

INTERCEPTORS AND APPURTENANCES

Along the waterfronts of the East and Harlem rivers the interceptors will be required to remove sewage and storm discharge to an amount practically double the ultimate dry weather flow. The interceptors will be provided with regulating devices for diverting the dry weather flow and the first flush of storm flows from the existing outlet sewers. Grit and coarse solids will be removed by screens and grit chambers. Tidal gates will be required to prevent river water from flooding the interceptors at times of high tide.

There are about 54 sewers to be intercepted in Manhattan and some 20 in the Bronx. The intercepted sewage will flow by gravity to low points in Manhattan, near 110th Street, and in the Bronx, near St. Ann's Avenue. At these two points grit chambers and screens will be installed. From each grit chamber separate tunnels will lead to the Wards Island Works, approximately as shown in Fig. 2. These will be in solid rock, probably about 300 ft. below the surface. The Manhattan tunnel will be 3,450 ft. long and 8 ft. 6 in. in diameter; and the Bronx tunnel, 5,400 ft. long and 10 ft. 6 in. in diameter. The two tunnels will terminate in uptake shafts from which the pumps will

take their suction through connecting conduits, from a flow line approximately 25 ft. below datum.

ACTIVATED SLUDGE PROCESS AND PLANT

Sludge is activated by aerating sewage for a sufficient time to permit the solid particles to become coated and impregnated with growths of oxidizing bacteria and other organisms. Such activated sludge, with gelatinous surfaces and oxidizing properties of a biochemical nature, is mixed with the sewage to be treated for three or more hours in an aerating tank well supplied with atmospheric oxygen. Here the suspended and colloidal matter in the sewage becomes attached to the activated sludge particles, and the dissolved organic matter is oxidized by the bacteria and their enzymes. The sludge is then separated by sedimentation, leaving a clear and well purified effluent. A portion of the sludge is returned to the inlet of the aeration tank and the excess is dried for use as a fertilizer, or otherwise disposed of.

One of the accompanying photographs, that of a model of the Indianapolis sewage disposal plant, shows how air is applied to provide spiral circulation in the aeration tanks for the furthering of oxidation as well as for a thorough mixing of new sewage and the portion of activated sludge returned to the inlet. If the raw sewage does not contain excessive quantities of industrial wastes this process can remove over 90 per cent of the suspended matter and saprophytic bacteria, 90 per cent of the biochemical oxygen demand, and from 95 to 98 per cent of the pathogenic bacteria. Thus it is superior to trickling filters. Not only does it produce a thoroughly satisfactory effluent, but it operates with complete freedom from odors and flies, on a minimum area of land and, without considering sludge utilization, at a lower investment cost than any other process giving comparable results for large projects. Because of the removal in the preliminary tanks of that portion of the sludge having a relatively low nitrogen content, the excess activated sludge is better suited for conversion into fertilizer—due to its relatively high nitrogen content—than is the sludge from the preliminary tanks or a mixture of all the sludge.

After the Wards Island site became available for the city's use, in the spring of 1927, a report recommending the activated sludge type of treatment was made by the Engineering Subcommittee to the Committee on Main Drainage of the Board of Estimate and Apportionment. This committee in turn reported to the board itself in November 1927. Shortly afterwards, the writer was appointed consulting engineer to review the proposed plan, and a special committee was appointed to inspect sewage treatment plants elsewhere in the country which used this process.

DEVELOPMENT OF PROJECT PLANS

On June 14, 1928, the Board of Estimate adopted a series of resolutions under which Wards Island was definitely designated as the site for an activated sludge treatment plant, and the presidents of the boroughs of Manhattan and the Bronx were requested to develop a drainage plan consistent with the Wards Island Project. The firm of Fuller and McClintock was employed as engineering designers. The project report and plans submitted in March 1929, included a complete layout for the whole treatment plant, together with reports describing the various parts of the work and a set of 37 plans showing the location and general arrangement of the project. These project plans, which were approved by the Board of Estimate and Apportionment on October 3, 1929, formed the basis for the preparation of the detailed design.

Plans and specifications for the entire plant were arranged in eight groups so that the work could be started promptly and go forward in conformity with construction needs. Briefly, the works are made up of the following principal parts having the general characteristics here described.

In the general layout, the principal structures are the pump and blower house, containing the main sewage pumps, the blowers, and the electric control; the preliminary settling tanks, where the heavier suspended matter will be settled out; the preliminary sludge pumping stations, housing grease and scum ejectors, and pumps for removing the settled sludge from the preliminary tanks; the aeration tanks, where air is admitted to the mixture of sewage and return sludge for agitation and aeration; the final settling tanks, where the remaining solids are separated from the liquid; the return sludge pumping stations, housing the pumps which return the sludge from the final tanks back into the system for recirculation, and which move the excess sludge to the sludge storage tanks or to the proposed fertilizer plant; the operating galleries, which house the gates and meters for controlling the flow to and from the aeration tanks and for regulating the withdrawal of sludge from the final tanks; and the sludge storage and decantation building, housing the tanks in which the excess sludge is stored previous to loading on the sludge boats and for decantation. In addition there

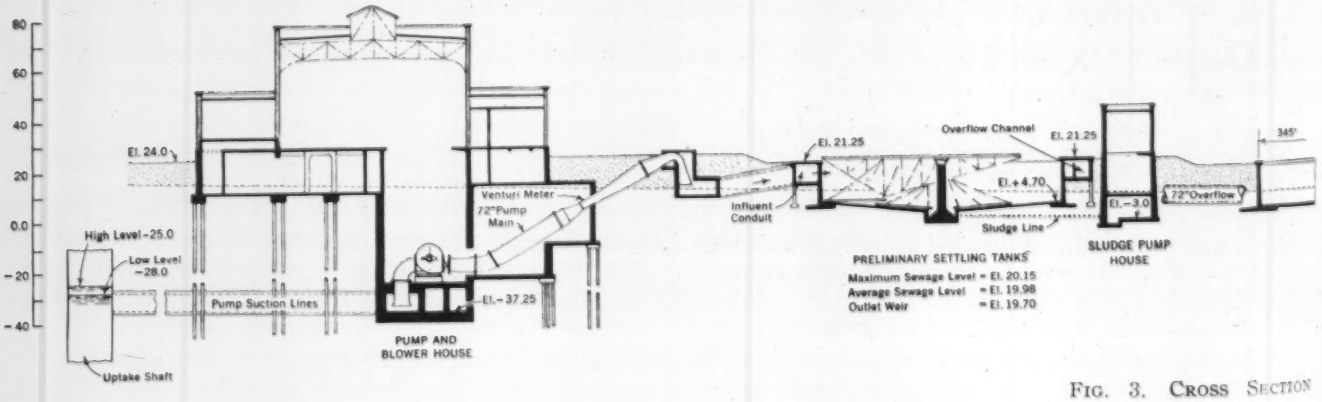


FIG. 3. CROSS SECTION

are a dock; a central heating plant, with oil-fired boilers; an administration building, housing the administrative offices and the laboratory for plant control; and a fertilizer plant, for demonstration purposes.

Sewage reaching the island from Manhattan and the Bronx will flow from the tunnel uptake shaft to the pump and blower house, where it will be raised some 46 ft. and discharged through conduits into the preliminary settling tanks. The settled sewage will then flow to the aeration tanks through conduits equipped with Venturi meters. Just before it reaches the aeration tanks the return activated sludge will be added. From these tanks the activated sewage will flow across the operating galleries to the final tanks. Here the clear liquid will be drawn off the top and discharged through conduits into the East River, while the sludge at the bottom will flow to the return sludge pumping stations. From there, a large portion, equivalent to some 25 per cent of the raw sewage, will be returned to the inlet conduits of the aeration tanks, and the rest will go to the sludge storage tanks at the dock, for loading into the sludge boats after some decantation.

In order to care for storm flows in excess of $1^1/_2$ times the average dry weather influx of 180 m.g.d., overflow weirs are provided in the effluent conduits of the preliminary tanks. After clarification in the preliminary tanks, the excess effluent passes over these weirs and through a conduit having a submerged outlet in the East River. A cross section through the works is shown in Fig. 3.

PUMP AND BLOWER HOUSE

The pump and blower house, which consists of a main building and three wings, is 346 ft. long by 146 ft. wide in plan. It has a maximum height from the ground floor to the roof of $44^1/_2$ ft., and a depth from the ground floor to the floor of the pump pit of $47^1/_2$ ft.

At the bottom of the pump pit are located six main pumping units consisting of horizontal centrifugal pumps, direct connected—four to synchronous motors and two to variable-speed motors—each having a capacity of 90 m.g.d. at a head of 50 ft. By combining the variable and constant-speed units, daily variations in the sewage flow can be cared for efficiently. The pumps discharge through siphons equipped with automatic breakers and electric-operated gate valves into a common conduit leading to the preliminary tanks. To provide against surge caused by the shutting down of a pump, or what is more serious, by power failure, a surge chamber is provided on the suction conduits just ahead of the pumps. This chamber is about 88 ft. long by 20 ft. wide, and extends 35 ft. above the average sewage level in the conduits. Computations indicate that with a chamber of this size the maximum possible surge will not raise the water surface in the surge chamber over 20 ft.

The blowers which furnish the air for the activation of the sewage in the aeration tanks are located on the main floor. There are six electric-driven direct-connected centrifugal blowers of the horizontal-shaft, two-stage type, each with a total capacity of about 250,000 cu. ft. of free air per minute when operating with a discharge pressure of 7.7 lb. per sq. in. The air will be drawn in through cell-type air filters into concrete ducts and steel suction pipes. At the suction end of the blowers the air will be at outdoor temperature. The capacity of the blowers will be sufficient to supply 1.2 cu. ft. of air per gallon of sewage for a flow 25 per cent in excess of the average, plus 5 per cent for loss in aerating conduits. However, it is expected that normally less than $^3/_4$ cu. ft. of air per gallon of sewage will be required.

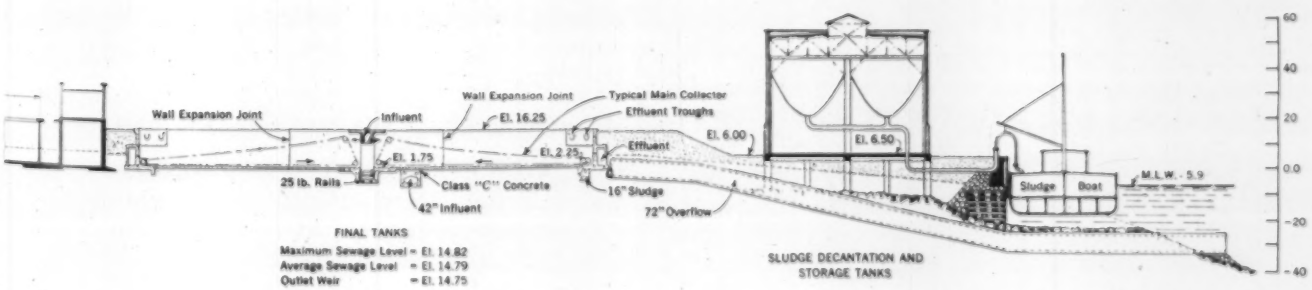
The north end of the station is devoted to the electric control. Electric power, for an approximate maximum load of 15,000 kva. will be furnished through three incoming feeders, each with a capacity of 9,000 kva. Power will be received at 13,200 volts. Part of it will be transformed to 4,000 volts, principally for distribution to the main sewage pumps and blowers; part to 440 volts, for the smaller pumps and other auxiliaries; and part to from 440 to 110 volts, for lighting throughout the works.

SETTLING AND AERATION TANKS

Eight preliminary tanks, each approximately 100 ft. square by 15 ft. deep, are equipped with revolving mechanisms for sludge removal, as shown in Fig. 4, and arranged for grease skimming. They provide for a retention period of about one hour at average flow.

The aeration tanks, 16 in number, each 88 ft. wide by 345 ft. long, with an effective depth of 15 ft., are of the spiral-flow type with curved baffles. They are divided into four channels through which the sewage flows in series. With one tank out of service, they give an aerating period of $5^1/_4$ hours at the average flow of 180 m.g.d. plus 25 per cent of return sludge. Air is admitted at the bottom of one side of each channel through double rows of porous plates. The arrangement of the air piping in these tanks is shown in Fig. 5.

Each aeration tank has its outlet piping so arranged



THROUGH THE PLANT

that the tank feeds two final settling basins. A Venturi meter located in the operating gallery measures the output of each aeration tank, so that this portion of the work is divided into 16 self-contained units.

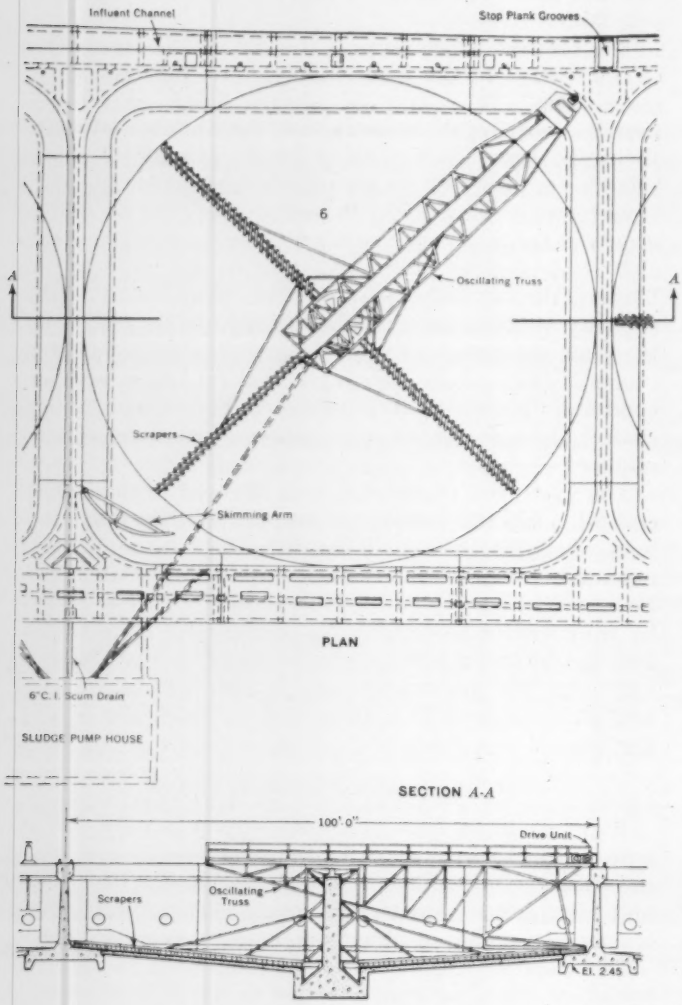


FIG. 4. DETAIL OF A REVOLVING-TYPE PRELIMINARY TANK

The final tanks are 32 in number, each with a surface area of approximately 7,500 sq. ft. and an effective depth of 12 ft. With two tanks out of service, and at average rates of flow, plus 25 per cent of return sludge, these tanks have a capacity of 1,000 gal. per sq. ft. per day. Sludge is to be continuously removed from these tanks by conveyors. In order to provide the competition required by the city charter it was necessary, both in the case of the preliminary and the final tanks, to prepare designs with different types of sludge removal mechanisms. After an examination of the bids, the revolving type was determined upon for the preliminary tanks, and the conveyor type for the final tanks.

As shown in Fig. 3, the aerated sludge enters the final tanks along the center line and flows both ways, and the effluent flows out over weir-edged troughs near each end. The settled sludge is drawn off at the bottom, in the middle, near where the sewage enters.

In the operating galleries (Fig. 3) will be installed the piping and controls for the delivery of air and mixed liquor to the aeration tanks, for the movement of aerated sewage from these tanks, and for the withdrawal of sludge from the final tanks. Sludge from the final tanks flows to sludge boxes in the gallery, which are equipped with control valves. From them it passes through conduits to the suction end of the pumps in the two return stations, which handle the return and excess sludge.

SLUDGE PUMPING STATIONS

There are four return sludge pumping units in each of two stations, each unit having a capacity of 15 m.g.d. against a 10-ft. head. The pumps are of the horizontal-shaft, screw type, direct connected to variable-speed motors. Their discharge, after passing through Venturi meters, is fed into the influent conduits of the aeration tanks. An amount of return sludge up to 50 per cent of the average sewage flow can be handled, although for normal operation the quantity will probably average around 25 per cent.

There are four excess sludge pumps located in each of the return stations, two with a capacity of 560 gal. per min., and two with that of 280 gal. per min., each at a total head of 50 ft. These pumps are of the horizontal reciprocating type, equipped with ball valves and connected to the driving motors by gears. They can draw sludge from either of two pairs of final tanks, so that this sludge can be given special treatment if it is found desirable. Also, they will pump the sludge either to the storage tanks at the dock, to the proposed fertilizer plant, or to the inlet of the preliminary settling tanks.

SLUDGE STORAGE AND DISPOSAL

For sludge storage there are four steel tanks of the suspension coal-bunker type, each with a net capacity of 45,000 cu. ft. of sludge, and provided with adjustable troughs, so that any clear liquid can be decanted off and carried back to the suction of the main sewage pumps. The settled sludge from the preliminary tanks and the excess sludge from the final tanks are pumped to these storage tanks and allowed to remain quiescent for a few hours. The sludge then flows by gravity to the boats.

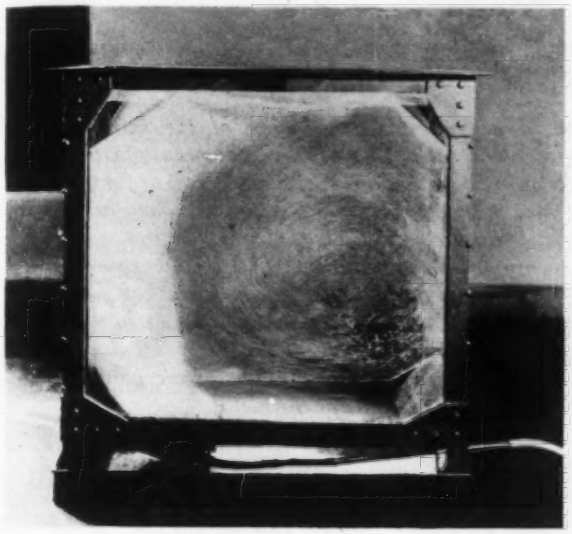
Three sludge vessels have been designed for the daily disposal of 5,000 tons of sludge at locations established by the Federal Government, at present 8 nautical miles east southeast of Scotland Lightship or about 12 miles from shore. These vessels will have a capacity of 1,500 tons and will be equipped with twin screws and Diesel engines. When loaded, their maximum speed will be $10^1/_4$ knots and their cruising radius, 2,700 miles. In a 24-hour day each boat will be able to make two trips, with a liberal allowance of time for loading and unloading.

EXPERIMENTAL FERTILIZER PLANT TO BE BUILT

An experimental fertilizer plant having a daily capacity of from 15 to 20 tons, is being designed. It is substantially equivalent to one drier unit, including storage for the finished product, and is so laid out that it can be advantageously extended in the future.

In view of the uncertainty of the nitrogen content of the sludge and of the marketability of fertilizer produced

from this sewage, it was thought best to start with an experimental plant which can be extended later to handle all the material from the Wards Island Sewage Treatment Works available for fertilizer, estimated at some 80 tons per day. In this plant sludge withdrawn from the final settling tanks will be conditioned by the addition of chemicals, filtered through vacuum filters,



SPIRAL FLOW IN MODEL OF INDIANAPOLIS PLANT

dried in oil-fired driers, and then screened and disintegrated to form the finished fertilizer.

ARCHITECTURAL TREATMENT STRESSED

Because of the rather conspicuous location of the works, which are in view of the traffic passing through Hell Gate, over the New York connecting railroad, and the Tri-Borough Bridge, now being built, considerable effort has been made to give the works an attractive appearance. Careful attention has been paid to the architectural features of the buildings and to the landscaping of the site.

An estimate in 1929, of the cost of the treatment works was, in round numbers, $18,000,000, including engineering and contingencies. The interceptors and tunnels to Wards Island are estimated to cost $12,000,000, bringing the total estimated cost of the Wards Island unit up to $30,000,000. It was estimated that it would take $4\frac{1}{2}$ years for completion after the letting of the

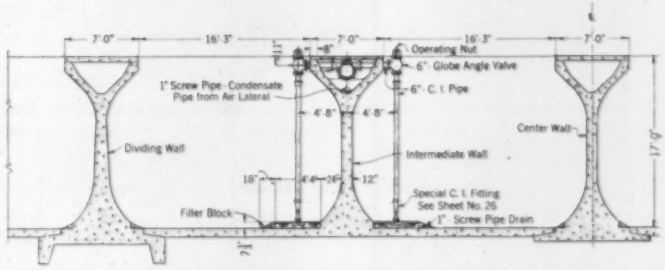


FIG. 5. SPIRAL FLOW AERATION TANK—HALF SECTION
Each Tank Symmetrical About Center Wall

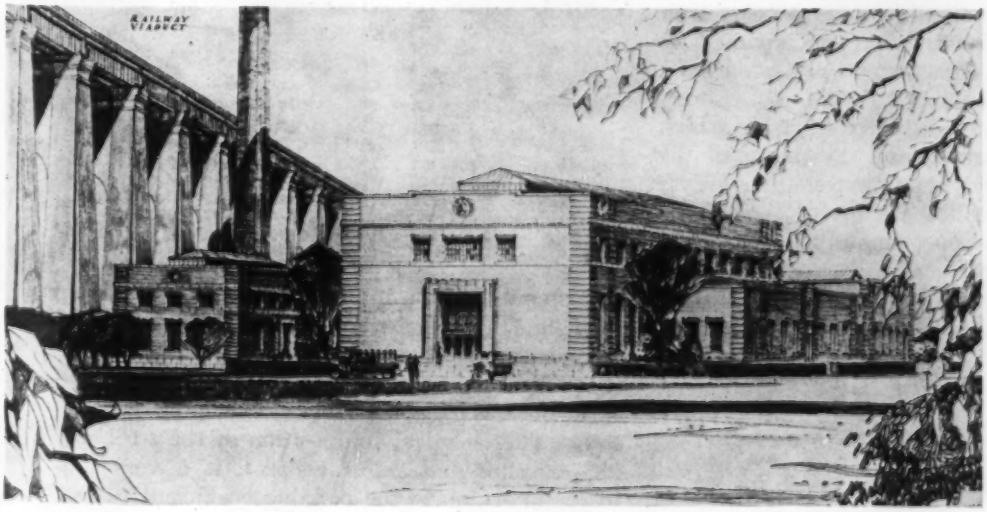
first contract. Two contracts, one covering the construction of the tanks, the operating galleries, and their appurtenances, and the other covering the dock, sea wall, and dredging, have been awarded to W. H. Gahagen, Inc., and Frederic Snare Corporation, respectively.

ACKNOWLEDGMENTS

The design of the works was commenced and the project plan completed under the direction of Hon. Julius Miller, President of the Borough of Manhattan; Clifford M. Pinckney, M. Am. Soc. C.E., Chief Engineer of the Borough of Manhattan; and Richard H. Gould, M. Am. Soc. C.E., Chief Engineer of the Wards Island Sewage Treatment Works.

In December 1929 a Department of Sanitation was created, to whose jurisdiction the Wards Island Project was transferred. The Sanitary Commission is made up of William Schroeder, Jr., Chairman; Leonard C. L. Smith, M. Am. Soc. C.E.; and Charles S. Hand. Since December 1929, the work has been carried out under the direction of Commissioner Smith, with Mr. Gould as Engineer for the Sanitation Department on the Wards Island Project.

In the prosecution of the work, the designers, Fuller and McClintock, have associated with them Sloan and Robertson, architects for the design of all superstructures; Cox and Stevens, Inc., Naval Architects for the design of the sludge vessels; and Noel Chamberlin, Landscape Architect, for the design of the landscaping features. The engineers, Fuller and McClintock, have also had as advisers and consultants the firm of Pearse, Greeley, and Hansen, Sanitary Engineers; Will J. Sando, Mechanical Engineer; J. T. Hawley, Electrical Engineer; and Silsbee and Gould, Marine Engineers.



SKETCH OF HEATING PLANT AND PUMP AND BLOWER HOUSE
Railway Viaduct at Left

Cracking of Reinforcing Bars at Cold Bends

Phenomenon Explained by Results of Extensive Swiss Tests

By Dr. Ing. Th. Wyss
Federal Testing Laboratory, Zurich, Switzerland

Translated and Abstracted by Albin H. Beyer
Member American Society of Civil Engineers
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At the first International Congress on Concrete and Reinforced Concrete, held in September 1930, at Liege, Belgium, Dr. Wyss presented a brief paper giving a simple but effective explanation of an embrittling phenomenon which occurs under certain conditions in ductile steels, in particular at the concave side of cold bends made in reinforcing bars. The steel on the inside of the bend undergoes plastic deformation in compression, which may be so great that when the bending forces are relieved the residual internal tensile stresses developed by cold bending may result in the formation of a crack on the inside of the bend. He showed that after ductile steel has been plastically deformed in compression 20 per cent or more, it becomes extremely brittle when subsequently subjected to tensile loads.

In my opinion, this embrittling phenomenon may explain some of the perplexing cases of failure where a very ductile steel part has broken in service as if the material in it were devoid of all ductility and under conditions where the break cannot be attributed to the fatigue of the metal.

A. H. Beyer

BREAKS frequently occur in the hooked ends of steel reinforcing bars either in transportation or during erection. Detailed tests on steel which had broken in this way showed that it met all the physical and chemical requirements of standard Swiss specifications. A careful examination of the fractures indicated that in general such cracks started at the section of maximum bending on the concave side of the bend and worked in, perpendicular to the surface, as seen in Figs. 1 and 2. Dr. Wyss concludes that cracks of this type can be attributed to the embrittlement of the steel and the internal tensile stresses resulting from cold bending. Because of the importance of this subject he undertook a comprehensive study of this phenomenon.

Straight rods bent both cold and hot were investigated. In order to determine the exact point in the making of a cold bend at which the crack developed, the load during bending was applied and removed in increments. The formation of the crack which always developed in the concave side during unloading was accompanied by a slight breaking sound. Tests were made on bars ranging in diameter from $^3/_8$ in. to $1^1/_2$ in.

In order definitely to establish the relationship which exists between the bar diameter and the radius of the bend in the making of cold bending tests, Dr. Wyss made use of the term "bending coefficient." This he denoted by K, where K is approximately equal to the plastic strain, expressed in per cent.

According to the notation given in Fig. 3, $l - l'$ represents the shortening on the inside due to the bending in a length l. Then,

$$\text{Plastic strain} = \frac{l - l'}{l} \frac{\frac{d}{2}}{r}$$

Per cent of plastic strain, or bending

$$\text{coefficient} = \frac{(l - l')}{l} 100 = \frac{50\,d}{r} = K$$

On investigation, the material showed the following physical properties:

Yield point	39,500 to 45,400 lb. per sq. in.
Tensile strength	55,300 to 61,900 lb. per sq. in.
Per cent of elongation in 10 diameters	26.8 to 33.9
Standard bending tests	all satisfactory

For this material the limiting values of the bending coefficient K, when cracks appeared during the cold bending of straight bars, were found to be:

As received	between 59 and 50
Annealed before bending	between 55 and 40
Bars bent hot to a diameter of $5d$, followed by additional cold bending	between 71 and 52

Most of the values recorded for the coefficient K ranged from 40 to 60, with a mean of 50. A coefficient of 40 corresponds to an inside diameter of bend equal to $1.5\,d$, and a coefficient of 60 corresponds to an inside diameter of bend equal to $0.66\,d$. These tests indicate that when the inside diameter of the bend approaches $1.5\,d$, there is danger of cracks developing on the concave side. The chemical composition of the steel, especially its phosphor and sulfur content, is a very important factor in so far as the bending coefficient is concerned. This is clearly shown in Table I. The steel in the bars which broke at the job had a materially higher phosphor

Table I. Chemical Composition of Steel in Reinforcing Bars, in Percentage

Description	Diameter in In.	Carbon	Silicon	Phosphor	Sulfur	Manganese	Phosphor and Sulfur
Laboratory specimens	0.394	0.05	0.00	0.06	0.045	0.51	0.105
	0.787	0.02	0.00	0.04	0.05	0.28	0.09
	1.181	0.025	0.00	0.06	0.07	0.34	0.13
	1.575	0.05	0.00	0.06	0.08	0.46	0.14
Specimens broken in the field	0.472	0.09	0.00	0.17	0.045	0.72	0.215
	1.496	..	..	0.13	0.06	..	0.19
	1.575	0.07	0.00	0.12	0.05	0.48	0.17

content than the steel used in this investigation. It is well known that the embrittlement resulting from high phosphor content is very pronounced when steel is bent cold.

DEFORMATIONS AT SECTION OF MAXIMUM STRAIN

In order to determine the plastic deformations which result from bending, points were marked on the test specimens at intervals of 1 cm. In the case of the straight rods, circumferential lines were used; and for the hooks, punch marks were made at the outer and inner surfaces.

Briefly, the following results were obtained:

1. The percentages of permanent elongation and compression in bending were substantially the same.
2. For cold bends made on steel as delivered, the limiting plastic deformation when cracking occurred ranged from 51 to 56 per cent; and for the same bars previously annealed, it ranged from 46 to 51 per cent.
3. When rods were bent hot, they could withstand further cold bending corresponding to an additional plastic deformation ranging from 33 to 45 per cent.
4. The percentage of permanent deformation coincided in many cases with the bending coefficient K.
5. In making cold bends on straight bars, there was danger of cracking when the plastic deformation amounted to about 50 per cent. Like the bending coefficient, this also varied with the chemical composition of the steel.

DETERMINATION OF TENSILE PROPERTIES IMPORTANT

As established by tests, the material within the zone in which the cracks appeared had been subjected by cold bending to a plastic deformation of approximately 50 per cent, and then, when the bending force was relieved on account of the residual internal stresses, an internal tension developed which resulted in an actual crack. It was important, therefore, to determine the tensile properties of similar steel which previously had been plastically deformed in compression. The results, given in Table II, indicate that as the amount of plastic compressive deformation is increased up to 50 per cent, the tensile strength of the material, with one exception, is raised. On the other hand, the percentages of elongation and contraction of area become practically zero when the previous plastic deformation amounts to 20 per cent. It is evident, therefore, that this material becomes extremely brittle when plastically overstrained in compression a certain amount. Figure 4 shows the various types of tensile fractures that were obtained with such steels when the material had been previously plastically deformed in compression various amounts ranging from zero to 40 per cent.

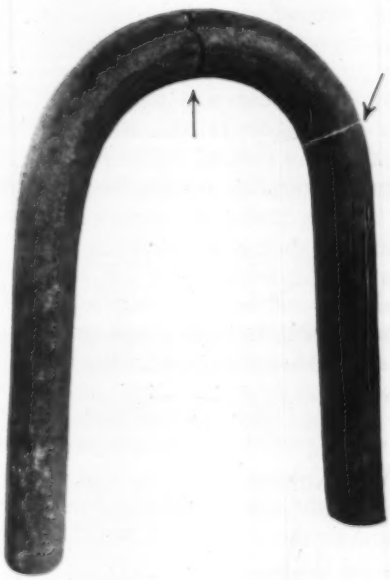

FIG. 1. CRACKS IN 1¼-IN. BAR AS A RESULT OF A SHARP COLD BEND
White Line Locates Secondary Hair Crack

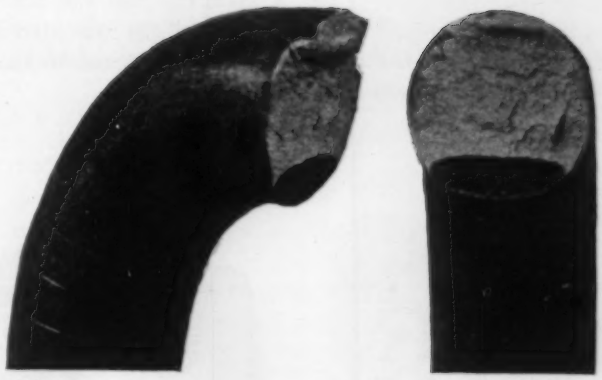

FIG. 2. TYPICAL FRACTURE OF 1¼-IN. REINFORCING BAR
The Original Crack, the Direct Result of a Sharp Cold Bend, Is Indicated by the Dark Area

STRESS DISTRIBUTION AFTER COLD BENDING

As already mentioned, the tensile fractures which developed on the concave side of the bend are the direct result of the internal tensile stresses which are developed at the inside of the bend when the bending pressure is released. A picture of such a stress distribution is shown in Fig. 3. The shaded portions of Fig. 5 (*a*) indicate the areas Q and R in which plastic deformations have occurred. At Q, where the compressive stresses have exceeded the yield point, a plastic shortening has occurred. On the other hand, at R, on the outside of the bend where the yield point in tension has been exceeded, the material has become plastically elongated.

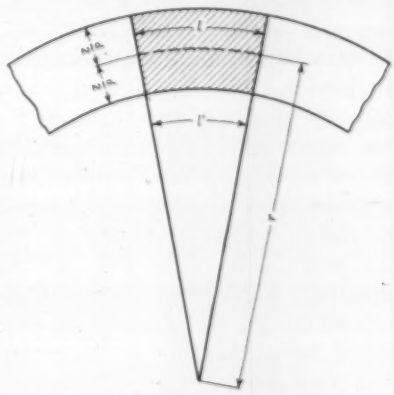

FIG. 3. DIAGRAM OF THE BEND IN A REINFORCING BAR
Showing Dimensions of Bent Part

On the release of the forces which produced the bending, the material near the neutral axis, which has been over-

TABLE II. TENSILE PROPERTIES OF 1¼-IN. REINFORCING BARS
Plastically Deformed in Compression from 0 to 65 Per Cent

ITEMS	PLASTIC DEFORMATION IN COMPRESSION, IN PER CENT						
	0	5	10	20	40	50	65
Proportional limit, in lb. per sq. in.	47,000	47,500	48,300	51,800	64,000	62,600	..
Yield point, in lb. per sq. in.	49,800	51,800	61,800	76,100	..	..	..
Tensile strength in lb. per sq. in.	68,000	75,300	83,000	82,900	77,000	90,400	68,300
Elongation in per cent in 1.57 inches	45.5	33.0	27.5	1.0	0.0	0.0	0.0
Contraction of area in per cent	64.0	60.0	56.0	0.0	0.0	0.0	0.0

stressed but little or not at all, exerts upon Q internal tensile stresses; and upon R, internal compressive stresses. Similar reciprocal effects are developed by the

materials in the zones Q and R upon the material which has been overstressed little or not at all, as indicated in Fig. 5 (*b*), where the principal stresses are shown in a rivet under the action of external forces.

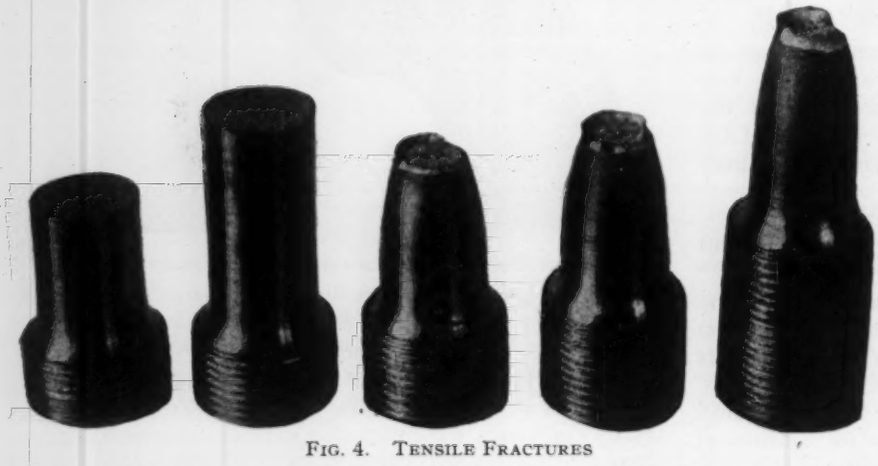

FIG. 4. TENSILE FRACTURES

In Steels Which Had Previously Been Plastically Overstrained in Compression by the Following Amounts (Left to Right): 40 per cent, 20 per cent, 10 per cent, 5 per cent, and 0 per cent

When these external forces are replaced by the internal stresses developed in the zones Q and R, there results the principal stress distribution shown in Fig. 5 (*c*). Under cold bending the internal stresses developed in a bar consist primarily of two sets of stress configurations. The solid lines indicate the direction of the principal tensions and the dotted lines, the direction of the principal compressions. At the mid-section, *0*, three critical points are designated by S_1, N, and S_2. All the principal tensile stress lines pass between S_1 and N, and all the principal compressive stress lines, between S_2 and N.

In Fig. 5 (*d*), the stress distribution at the cross section *0 0* is shown, on the assumption that all cross sections remain plane surfaces, that the zones Q and R extend almost to the center of the bar, and that when the yield point is reached the resultant stresses remain substantially constant. The four stress zones shown in Fig. 5 (*d*), alternating in sign, are thus developed. A somewhat similar distribution results for other cross sections taken parallel to *0 0*. There being no external forces on the bar, the internal forces must satisfy the conditions of equilibrium, which are as follows:

$$Z_1 + Z_2 - D_1 - D_2 = 0$$

$$Z_1 a - D_2 b - Z_2 c + D_1 d = 0$$

Actually the stress distribution is not as symmetrical as shown, for above the yield point the stress-strain diagram in tension differs from that in compression. Further investigations should therefore be made to determine more accurately the actual stress distribution at the bend. This applies especially to round shapes where a three-dimensional stress analysis must be made.

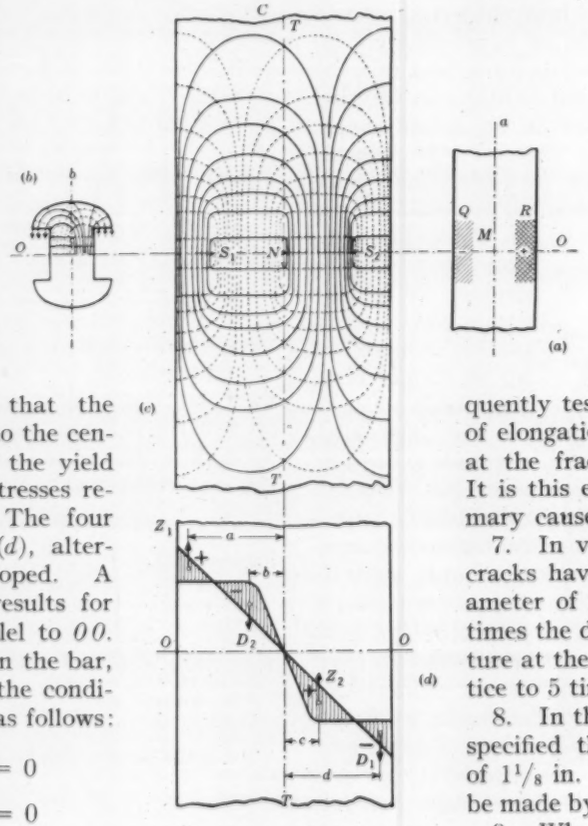

FIG. 5. STRESS DISTRIBUTION DEVELOPED BY COLD BENDING At Bend in Rectangular Bar

RESULTS IN BRIEF

These investigations and the conclusions deduced from them may be summarized as follows:

1. Cracks may develop on the concave side of cold bends made on reinforcing rods having dimensions and bends used in practice.

2. Assuming a normal quality of steel, that is, one having not more than 0.06 per cent of phosphor and 0.05 of sulfur, the danger point, irrespective of the diameter of the bar, occurs when the clear opening of the bend is equal to, or less than $1\frac{1}{2}$ times the diameter of the bar.

3. Breakages have occurred in practice with inside bend diameters ranging from 3.5 to 4.1 times the diameter of the bar. In all such cases a higher phosphor content than that noted was found.

4. When the plastic compressive deformation resulting from cold bending amounts to about 50 per cent, cracks are likely to develop. For materials of similar quality, this value is also independent of the diameter of the bar. In general, for materials of different chemical composition, it varies with the bending coefficient.

5. In many cases the plastic deformation in compression, expressed in per cent, and the bending coefficient K, coincide.

6. A steel deformed plastically in compression about 50 per cent was found to be extremely brittle when subsequently tested in tension. The percentage of elongation and the contraction of area at the fracture became practically zero. It is this embrittlement which is the primary cause of cracking.

7. In view of the fact that in practice cracks have occurred when the inside diameter of the bend ranged from 3.5 to 4.1 times the diameter of the bar, the curvature at the bend should be limited in practice to 5 times the diameter of the bar.

8. In the interest of safety it should be specified that for bars having a diameter of $1\frac{1}{8}$ in. or more, all end hooks should be made by hot bending.

9. Wherever bends sharper than 5 times the diameter of the bar are required, they should be made only by hot bending.

Educating the Civil Engineer

A Composite Picture of American Engineering Colleges

By H. P. Hammond

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ARE more engineers being graduated each year than the profession can absorb? Should they be more broadly or more technically trained? Should the curriculum be lengthened? Are there too many engineering colleges, providing too many diverse curricula? Are the teaching staffs of proper caliber? Should only 40 per cent of the students who enter engineering school graduate? All these questions are of importance to the profession. In this article Professor Hammond draws from his own rich experience and from the investigations made by the Society for the Promotion of Engineering Education to make a summary of important facts and problems relating to the training of engineers, which may point the way to more definite conclusions.

EACH fall some 25,000 young men enter the colleges of the country to become a part of our total engineering enrollment of 75,000. This group constitutes nearly one tenth of all the college students of the nation and is the largest single undergraduate group, excepting only that enrolled in the liberal arts and in teacher training courses. Four years later, upward of 10,000 of these engineering students, including over 2,000 young civil engineers, graduate to enter practice. This steady stream is by a wide margin the largest source from which the engineering profession is being recruited. From one fourth to one fifth of the civil engineering graduates become juniors in the American Society of Civil Engineers within a year of graduation. These figures alone are probably sufficient evidence of the importance of the proper training of these young men, not only to our Society but to the profession at large.

Approximately 165 institutions in the United States and its possessions and in Canada offer engineering courses leading to degrees. It is not possible to give the exact number since no definite line can be drawn between institutions that do, and those that do not, offer legitimate engineering programs. In addition, about 100 junior colleges offer work in engineering more or less equivalent to the first two years of the four-year curriculum; a smaller group of institutions, perhaps 30 in number, offer short courses in engineering not on the college level; and there are also the correspondence schools—including the extension divisions of some of our well known universities, which offer nonresident courses that may be accepted in partial fulfillment of the requirements for an engineering degree. Only collegiate engineering education is dealt with here, but the importance of other types of institutions should not be overlooked in any general study of the field.

Possibly because it is the oldest, and because it is less expensive than some of the other divisions, civil engineering is offered by more engineering colleges than is any other one branch. Approximately 150 colleges offer degree courses in civil engineering. One of the first aspects of this group of institutions that strikes any one who studies them is their great diversity. Without attempting to give an accurate classification, the following types may be mentioned:

Privately endowed schools of technology, such as Rensselaer, Massachusetts Institute of Technology, and Case (a relatively small group of about a dozen institutions, but one that has been largely responsible for fixing many of the characteristics of engineering education)

Privately endowed universities and colleges such as Yale, Harvard, and Pennsylvania (the largest single group)

State universities, including the land-grant universities, such as Michigan, Illinois, and Wisconsin (a large and powerful group)

Land-grant colleges, such as Pennsylvania State College and Iowa State College (also a large and important group)

Schools of mines

Municipal universities, such as Cincinnati and Akron

Military colleges

Sectarian institutions

Y. M. C. A. colleges

A few purely proprietary schools

This is a very heterogeneous group, as heterogeneous as are colleges in general, not merely so because of any arbitrary scheme of classification but actually so, in facilities, in staffs, and in standards of work.

These colleges range, in enrollment, all the way from Purdue, with its 3,000 engineering students, to some institutions with less than 25; in staffs, from Massachusetts Institute of Technology with over 500 teachers and assistants, to some with but one engineering teacher, or even with none; and in facilities, from Massachusetts Institute of Technology with an investment in plant and endowment of nearly $50,000,000 and an annual operating expense of about $4,000,000, to those with very small investments and expenditures indeed.

At the upper end of the scale of our engineering schools we have some of the strongest institutions in the world. At the other end we have such institutions as Blank College, which lists an engineering curriculum in its catalogue but has not a single genuine engineering subject nor a single teacher of engineering; and as Dash College, which offers six complete curricula under an "engineering faculty" consisting of one professor of engineering, one assistant professor of engineering, an instructor in flying, three teachers of general scientific subjects (whose names also appear elsewhere in the catalogue under other divisions of instruction), and one individual designated as "assistant in engineering and assistant football coach." While the two last mentioned are real institutions, they are not, of course, representative of the general run of engineering colleges. They are, however, a part of the general picture of engineering education in this country.

There are probably not less than 25 institutions that we could very well dispense with—ones that not only have low standards but that give little or no promise of ever being anything but mediocrities, or

less. Even more than the profession itself, engineering education, in general, is "open" to any one wishing to practice it. Only in certain sections of the country is the establishment of engineering colleges effectively limited by law. The importance to the profession of the nature of institutions that can and do offer engineering need not be dwelt upon further.

Before leaving the subject of engineering colleges, some additional light may be thrown on the subject by picturing a hypothetical "average" engineering school, toward the middle of the group of all engineering colleges. It would be a component part of a university. The general subjects, including English, mathematics, physics, and chemistry, would be taught in the general academic departments, while the engineering subjects proper would be taught in the engineering college. It would offer four or five undergraduate curricula—civil, electrical, mechanical, chemical, and perhaps mining. It would have an enrollment of from 450 to 500 engineering students, and would graduate from 70 to 80 each year, including from 15 to 20 civil engineers. From 40 to 50 of its teachers would devote all or the major portion of their time to the teaching of engineering students. It would have assets devoted to engineering—including a pro rata share of the general facilities of the institution—of, roughly, from $2,000,000 to $3,000,000. It would expend about $250,000 per year to provide its engineering instruction, of which the students would pay considerably less than half in tuition fees. It would have a moderately adequate layout of buildings and laboratory equipment, but would need more. Its teaching staff would be a group of earnest and generally competent men.

HIGH LIGHTS IN ENGINEERING EDUCATION

Approximate Figures

Total Enrollment in Institutions of Engineering Education	75,000
Engineering Students Graduated Annually	10,000
Civil Engineers Graduated Annually	2,000
Total Investment in Educational Equipment	$375,000,000
Equipment Investment per Student	$5,000
Total Operating Expense—of Which Teachers' Salaries Approximate 50 Per Cent	$35,000,000
Operating Cost per Graduate	$3,000
Operating Cost per Student per Year	$500
Total Cost to Community, Including Students' Living Expenses, per Graduate	$10,000 to $12,000
Average Annual Earnings After Graduation:	
0 Years	$1,500
10 Years	$4,000
20 Years	$6,000
30 Years	$7,500

TYPES OF PROGRAMS AND CURRICULA OFFERED

Engineering is offered under several different plans: the usual all-residence course of four years leading to the bachelor degree, the student being registered in the engineering college from the day of his admission; the divided curriculum, under which the student pursues the first two or three years of his work in the college of liberal arts, and the last two or three years in the engineering college; the cooperative plan, by which he alternates between college and industry at intervals of from two weeks to a semester, during all or a part of his course; evening courses leading to degrees; and a combination of correspondence and residence work. The great majority of colleges offer the usual four-year, all-residence type of program; 4 offer what have been called "divided" curricula; 18 offer cooperative courses; and 7 offer degree courses in the evening. Correspondence work does not play a very important part in collegiate engineering education.

No fewer than 78 different engineering curricula and "options" are offered by American engineering schools. In addition to the five major branches of civil, electrical, mechanical, chemical, and mining and metallurgical, there are such variations as the following: administrative, aeronautical, architectural, agricultural, coal mining, commercial, construction, commercial-electrical, ceramic, engineering-physics, engineering-law, electro-chemical, electro-metallurgical, fire protection, forest, flour mill, and others far too numerous to mention here. This tremendous number and diversity of curricula is unique in higher education. To an outsider it would appear that we are attempting to provide specific training programs for every minor subdivision of engineering practice in which graduates may possibly find themselves. It should be pointed out, however, that while this great diversity of curricula exists, over 80 per cent of all our students are enrolled in the five major engineering divisions, and that over two thirds are registered in the three first mentioned.

In the general divisions of engineering education that we are accustomed to call civil engineering there are 21 different undergraduate curricula offered in American colleges, as well as 18 different "options," that is, curricula modified to a greater or less degree from a major curriculum, but having a considerable content of the same subject matter. It should be remembered that these are undergraduate, not graduate, curricula, which must usually be elected by the student before he enters his junior year. However, it should be pointed out that while all these curricula exist somewhere in the country, most institutions provide but one general curriculum in civil engineering.

Of recent years there has come about quite general agreement that the aim of undergraduate curricula should be to provide a broad type of training without much effort toward specialization, but it would appear that there is some difference of opinion as to how this may be best accomplished, since there is considerable diversity among colleges in the number and types of curricula offered. The range is from one institution that offers 22 undergraduate curricula and options, to another that offers but one, the announced purpose of which is to provide a type of training broad enough to equip its graduates for eventual service in any branch of the profession.

IS THE CURRICULUM OVERCROWDED?

One of the most striking characteristics of engineering curricula, and one frequently discussed, is that they require

in four years fully the equivalent of five years of the usual liberal arts program. Not only does engineering have a much larger number of prescribed "credits" (a median of 149 as compared with 120 in liberal arts) but each credit, on the average, is more difficult and requires more outside preparation. It is a serious question whether more work is not required of the engineering student than he can be expected to do thoroughly and well. On the average, he carried 7 different subjects of instruction at one time (in some instances as many as 12) and spreads his interest and effort over an equal number of fields. He is held accountable by 7 different teachers and must pass an equal number of final examinations each semester.

This "overcrowding" of curricula has led in recent years to a perceptible decrease in the requirements for graduation—about 10 per cent in the past 15 years. A goodly number of engineering educators believe that the requirements might be still further reduced, with profit and in the interests of thoroughness. It would seem reasonable to expect that, if the student could devote the same amount of time he does at present to fewer subjects, he would do each of them more thoroughly, and engineering education might thus be relieved of the criticism of lack of thoroughness which is sometimes made against it.

A graphic presentation of the content and organization of a typical civil engineering curriculum is shown in Fig. 1. Its purpose is not only to show the content but to indicate in a rough way the relationship of courses. This relationship is one of the distinctive characteristics of engineering in comparison with many other divisions of undergraduate work and, be it said, one of the genuine advantages which engineering possesses. Generally speaking, the curriculum is an articulated and coherent whole. There are few, if any, unrelated fragments of subject matter. All its parts bear upon one fairly definite objective. Sequences of subjects, such as that beginning with mathematics and physics, and extending through mechanics, mechanics of materials, stress analysis, and structural design, continue throughout the curriculum from the very beginning to the end—sequences that cannot be broken without disrupting the whole scheme of instruction. In them the student is led from general physical laws and mathematical processes to more and more concrete applications, each succeeding subject amplifying those that precede and giving opportunity for drill on fundamentals. It is this characteristic of coherent structure that is one of the chief contributing factors to the essential soundness of a civil engineering education.

Another characteristic displayed by the chart is the presence of a more or less well articulated series of general or "liberal" subjects, including English, history, economics, and other humanistics. This is an indication that an effort is made to include at least some of the elements of a "liberal education." There has been a distinct trend throughout engineering education in recent years to add more work of this character at the expense of the technical specialties, but without decreasing the amount of time devoted to mathematics and the physical sciences. This is very generally believed to be a move in the right direction, but it is one that should not be carried so far as to denature the essentially scientific and technological character of the program.

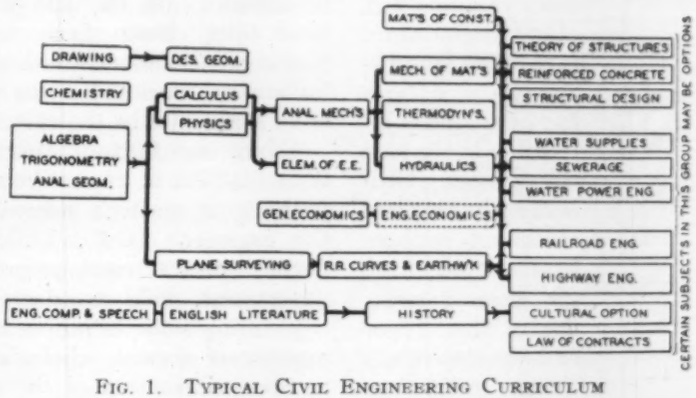


FIG. 1. TYPICAL CIVIL ENGINEERING CURRICULUM

ENGINEERING STUDENTS AN AMBITIOUS GROUP

Over seven eighths of all students who enter engineering courses are admitted directly from public high schools "on credentials," that is, on their diplomas, which the colleges accept as evidence that they are prepared to pursue college work. This admission procedure is obligatory on most of the publicly supported institutions and is also followed by a large majority of those that are privately supported. The extent and quality of the preparation which the student secures in the public high schools is, therefore, the factor that definitely fixes the point of beginning of college work. There is much discussion of the adequacy of this preparation and it is generally felt throughout engineering education that much is to be desired in the quality and extent of secondary schooling.

Whatever the merits of this discussion may be, it is a fact substantiated by the results of every comparative test I have ever seen, that those who enter engineering courses are the best students, scholastically, of any group entering college. For the most part they are serious minded and ambitious and have a fairly definite purpose in going to college, although their conception of what an engineering career means leaves much to be desired. It may be stated, in fact, that about 5 students out of 8 who enter engineering courses as freshmen have made their decisions on the basis of very inadequate knowledge of the field they have chosen. It is in this connection—in furthering the dissemination of accurate information about engineering as a career, among young men, their families, and advisers—that the organized engineering profession could be of real service not only to engineering colleges but to the profession generally.

Our engineering students come for the most part from homes of very modest means. They are of good American parentage. Approximately 9 per cent of their parents have college educations, and about 4 per cent of their fathers are engineers. A considerable proportion are largely dependent upon themselves for support during college. One institution reports that over two thirds of its students earn a considerable part of all their expenses during their undergraduate years.

Of all the engineering students who enter college,

approximately 30 per cent graduate with their class in four years, and an additional 10 per cent graduate later. The others, 60 per cent, are eliminated from college chiefly because of scholastic difficulties. The progressive shrinkage in a group of 100 entering students who proceed normally and graduate on schedule time is shown in Fig. 2. This ratio of eliminations is higher than in any other division of college work for which figures are obtainable. Another fact of some significance is that the percentage of eliminations has been slowly increasing in the past few decades. Generally speaking, the older and stronger institutions have the lower percentages of eliminations and the newer and weaker institutions have the higher percentages.

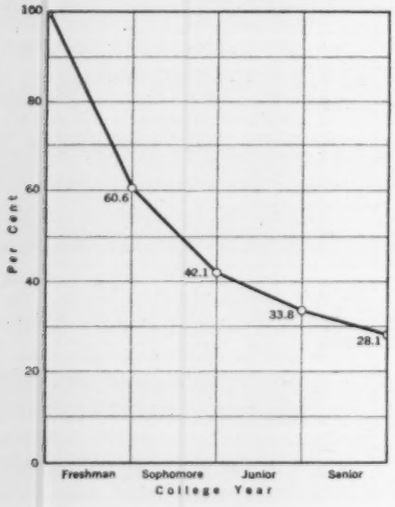


FIG. 2. ACADEMIC SURVIVAL OF ENGINEERING STUDENTS
Based on Records of 5,338 Students at 25 Institutions

Only a minor proportion of these eliminations (less than one third) are due to illness, lack of funds, change of family circumstances, and other factors not related to the student's college work. The major cause is scholastic difficulty, the chief contributing factors being poor preparation, lack of ability, poor choice of career and consequent lack of interest and, to an undetermined degree, the distractions of college life. The cure for the situation, no doubt, must be found partly in better methods of selection and admission, partly in better teaching, and partly perhaps, in better methods of dealing with the student as an individual.

For the most part, engineering students—certainly those who survive beyond the first two years of their college course—are conscientious in their work. The exactions of the engineering curriculum, which are very real, may tend, as some say, to make them task-doers and assignment-meeters to too great a degree. They may even have had their initiative and originality dulled rather than stimulated by the continual grind of piecemeal day-to-day assignments, but the fact, substantiated by their records after graduation, is that they are pretty well equipped to go out in the world and meet its competitions and to do truly constructive things.

MOST TEACHERS ENCOURAGED TO PRACTICE

The faculty of the hypothetical "average" engineering college previously mentioned is presided over by a dean who has fairly extended administrative and executive authority. It is organized by "departments" of civil, electrical, mechanical, and other engineering branches, each with a senior professor as "head of the department," and its administrative officer. About one fourth of its members have the rank of professor; about one third are associate and assistant professors, and the balance are instructors and "assistants." This group is a fairly mature and a relatively stable one, having less than 7 per cent of replacements per year. About one third of the faculty have been recruited directly from graduating classes of the same or of other institutions without any experience after graduation either in teaching or in practice; another third have been drawn from the field of practice; and the balance have been chosen from faculties of other colleges. Not more than one third are graduates of the same institution, thus indicating less "inbreeding" than is often claimed to be the case.

About one fifth of this average group, including both teachers of engineering and of science, hold the doctor's or master's degree; about two thirds hold the engineer's (C.E., M.E., etc.), or the bachelor's degree; and a small proportion, chiefly in the shop department, hold no degree. The teachers of the engineering subjects proper have a considerably smaller amount of formal scholastic training than an equal number of teachers of the sciences. The percentages of teachers of engineering and of teachers of science holding the doctor's degree is, in fact, about 5 and 30, respectively. The engineering teachers, on the other hand, have had much more extended contact with work outside of teaching.

It is perhaps relevant at this point to remark that the extent of post-graduate training of engineering teachers is by no means the sole ground upon which the extent of their education should be judged; nor should the holding of post-graduate degrees be made the criterion, as has been advocated in academic circles of late, upon which eligibility for advancement to the higher teaching posts should be based. This is not intended to imply any undervaluation of post-graduate training for engineering teachers, but at the same time it should be recognized that some of the most eminent men in the profession have acquired through professional engineering practice a breadth of education impossible to acquire in strictly academic surroundings.

Upon first appointment to a teaching position, if this followed immediately after graduation, a member of this average faculty group would earn the same or very slightly more than his classmates who had gone into practice. In other words, the college finds it necessary to pay the prevailing rate for graduates in order to secure them as teachers. From the first year onward, however, the earnings of the teacher become progressively less than those of other graduates. In Table I, which follows, the academic salaries and total incomes of teachers are compared with the earnings of other engineering graduates.

TABLE I. RATIO OF TEACHER'S EARNINGS TO THOSE OF OTHER GRADUATES

YEARS OF EXPERIENCE	RATIO OF TEACHERS' SALARIES TO EARNINGS OF OTHER GRADUATES	RATIO OF TEACHERS' TOTAL INCOMES TO EARNINGS OF OTHER GRADUATES
0	1.02	1.02
1	0.83	0.97
2	0.81	0.905
5	0.70	0.82
10	0.64	0.775
20	0.61	0.76
30	0.56	0.74

These statistics are for the period preceding the present industrial depression. The actual salaries and total incomes of teachers may be obtained by using these ratios with the data in Fig. 3. It is distinctly not intended by this comparison to imply that teaching and practice, as careers, should be judged solely on the basis of earnings.

It may be of some interest to state the extent to which teachers of engineering engage in professional practice outside of teaching. About 60 per cent of the younger men do some outside work. This ratio increases to about 75 per cent at 10 years after graduation, and to approximately 90 per cent 25 years after graduation. Earnings from these activities are not large, on the average. In the case of younger teachers, they average about $300 per year. For older teachers the amount is higher and reaches an average of about $1,500 per year among the older men. Most of the colleges not only permit but encourage their engineering teachers to engage in practice or research in order to keep abreast of developments in their fields. In only a few instances is such professional practice forbidden, or so discouraged as to be virtually forbidden.

It would perhaps be appropriate to conclude these excerpts from data relating to engineering faculties with something by way of appraisal of the standards of instruction prevailing in engineering education. It is very difficult for any one, and particularly for one who is himself a teacher, to make such an attempt. The best that I can do is to venture the rather subjective conclusion—based upon extensive contacts with college faculties during the past seven years—that the general standards of instruction in engineering do not suffer at all by comparison with those in any other division of undergraduate work.

COST OF EDUCATION

The direct costs—operating expenses only—of engineering education in this country are estimated to be between $30,000,000 and $40,000,000 per year, or approximately $500 per student per year. The cost per graduate is approximately $3,000. These costs include only the direct expenses, of which teachers' salaries constitute about 50 per cent. The investment in engineering education facilities is estimated to be about $5,000 per student, or a total of from $350,000,000 to $400,000,000. These figures do not include the total cost to the community, since the expenses incurred by students for living, books and supplies, and other purposes, and their loss of earnings during undergraduate years are not included. A rough estimate would indicate that the total cost to the community of every engineering graduate is from $10,000 to $12,000. This is probably slightly greater than the costs in liberal arts or business administration courses, but is doubtless less than half the cost of training a physician. The "cost to the community" does not, of course, consider the eventual return from the added value of the graduates' services.

Some slight indication of the worth of such services is given in Fig. 3, which shows the earnings, during the year 1924–1925, of graduates having various amounts of experience after graduation. All supplementary data tend to verify the general accuracy of the figures given in this chart. The earnings of civil engineering graduates do not differ materially from those of the entire group of engineering graduates as given in the diagram.

GENERAL STATUS, TRENDS, AND PROBLEMS

It is well to recall that civil engineering education is designed to fit, as well as may be, the requirements for

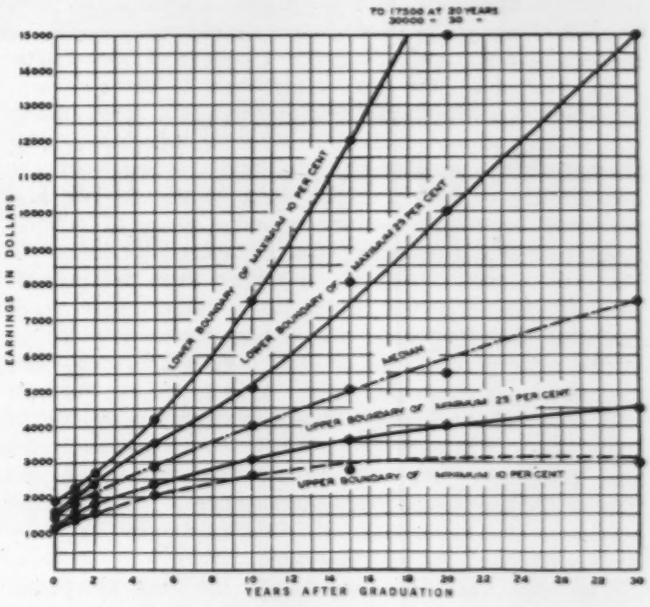


FIG. 3. RANGE OF EARNINGS OF 5,023 ENGINEERING GRADUATES
Based on Statistics for 1924–1925

one of the most diversified activities of modern society. At one end of the scale it merges imperceptibly with pure science, and at the other end, with commercial business. The range of responsibilities pertaining to positions in its field is also extremely wide—from executive control of great industries and railway systems to very minor jobs such as tracer or rodman. It is quite natural, therefore, that the aims of civil engineering education should be something of a compromise. It is probably correct to say that it is based much more upon the technical aspects of engineering practice (research, design, and construction) than it is upon the administrative or operating aspects; and it is probably right that this should be the case, since a more definite and generally sounder type of training can be provided on such a basis. It is also probably true that our curriculum is intended to prepare men, in general, for the higher, rather than for the more subordinate, types of positions. Nevertheless, and whether it is or is not a desirable condition, it is a fact that the engineering colleges are the chief source from which men must be drawn to fill a goodly proportion of rather minor technical positions. Until there can be developed in this country on a very much more general scale than at present—such, in fact, as prevails in most European countries—a type of sub-collegiate technical institution, there is bound to be a good deal of confusion in the aims of engineering education.

In its principal characteristics, civil engineering education partakes as much of the nature of general academic training as it does of strictly professional discipline. It does, of course, have many of the ele-

ments of a professional training—using that term in its commonly accepted sense—particularly in the last two years of the course. But it also has to an important degree, and particularly in the first two years, the characteristics of a more general academic education. It is a fact not generally understood that nearly half the requirements for the first degree in engineering (including the work in mathematics, physical science, English, foreign languages, and economics) would be acceptable toward the degree in a college of liberal arts.

In spite of a good deal of agitation to the contrary, engineering will probably remain for a long time among the undergraduate divisions of higher education. Although there has been not a little discussion of the advisability of giving it the same status as law and medicine by requiring two or more years of general academic preparation in college before admission to the professional school, there is very little prospect at present that this will be done. Further, it is very probable that four years will remain the normal length of the undergraduate curriculum. It is likely that the evolution toward higher levels of engineering training will come about through the superposition of one or more years of post-graduate work on the present four-year program. The best indication of this is the fact that in the past seven years the number of post-graduate students of engineering has trebled—from 1,000 in 1924–1925 to 3,000 in 1930–1931.

The fact that the preparation afforded by public high schools places a very definite limitation upon the scope of civil engineering curricula has been referred to previously. It is earnestly to be hoped that a process of "selective admissions" will lead in time to the solution of this problem through the acceptance by engineering colleges of only those students who are mentally equipped and properly prepared for the study of engineering. There is a very long journey ahead of us in this direction, however. Another aspect of the admission problem that has developed in recent years is the very rapid multiplication of junior colleges. These generally provide, or attempt to provide, the first two years of the engineering program. In so far as this development has led to the sifting out of students of poor ability before entry into the engineering school, its results have been beneficial. But in general it is causing many engineering colleges very serious difficulties. The fact that so many graduates of two-year "pre-engineering" courses require three years to complete their work in the engineering school proper is probably sufficient indication of the problems incident to this situation.

In spite of some pressure, engineering will probably continue to maintain what has been referred to as the "unitary" or coherent type of program. If there are to be any considerable changes in the curriculum—and if the trends of the past few years can be taken as any guide to what those changes may be—they may be expected to take the direction of somewhat simplified programs, with slightly fewer "credits" required for graduation, subjects of broader content, more emphasis on the fundamental sciences and less on the engineering specialties, and a somewhat increased scope in "humanistic" subjects. It may also be expected—which indeed is coming about at present—that increased attention will be devoted to the economic and financial aspects of engineering work, and that there will be somewhat greater freedom in the student's choice of electives.

One of the aspects of preparation for a professional career that may be looked for in vain in most civil engineering curricula is provision for introducing the student to what may be called the professional attitude toward his calling. With a very few exceptions, civil engineering curricula provide no means of acquainting the student with the ideals of professional practice, nor do they give any introduction to the business and financial relationship between the engineer and his client or employer. There is, perhaps, some reason for doubting whether matters like these can be properly presented through any scheme of formal instruction, and least of all, in all probability, could any good result come from preaching at students about them. Yet there would seem to be a real problem in this connection, for which a solution might be found. It may be that engineering schools could look to the profession for help in arriving at it.

Another absence that will be noted is instruction in the history of engineering. Only a very few schools provide work of this nature, although such of them as have attempted it have generally done an excellent job. If any one new element, aside from increased attention to the teaching of economics, can be added with profit to engineering instruction, it would seem to be in the history of the profession.

To return for a moment to the more general aspects of civil engineering education, it may be said with reasonable certainty that probably it will not become standardized (or subject to the control of outside standardizing agencies) to the same extent as has been the case in many other divisions of training for the profession. While it is true that on the whole engineering education has remained essentially sound both in ideals and in quality of work, and while the great majority of colleges have been not only maintaining but steadily enhancing their positions, it is, nevertheless, a disconcerting fact that of recent years the increased public recognition of the importance of engineering has led to the addition to the existing small, and probably inevitable, proportion of rather weak institutions, of a number of "engineering colleges" that the profession cannot regard with equanimity.

In conclusion, attention should be called to two trends in engineering education, both of which augur well for its future. One is the clearly discernible tendency of the engineering teaching profession to scrutinize more critically its own aims and methods and to attempt, through concretely practical means, to bring about improvements. The two nationwide surveys of engineering education that were completed during the years from 1914 to 1929, and the establishment in 1927 of the Summer School for Engineering Teachers may be mentioned as among the tangible evidences of this tendency. The other trend is in the direction of a much closer relationship between the profession and the institutions from which its recruits are drawn. There seems to be no disagreement as to the fundamental desirability of this movement. Whatever the profession can do to strengthen the agencies that provide for the training of its prospective members will accrue to its lasting benefit.

CORN PRODUCTS REFINERY CONSTRUCTED BY MODERN METHODS AND NATIVE LABOR

Modern Factory Built in Korea

By WELLS N. THOMPSON

ASSOCIATE MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
FORMERLY MANAGER, JAPAN BRANCH, THE H. K. FERGUSON COMPANY, CLEVELAND

IN a territory where the rumblings of war are now being heard, at Chosen, in northern Korea, a large group of modern steel and concrete factory buildings and a 1,500-kw. steam power plant have just been completed. American construction equipment and methods were successfully used except for the large amount of earthwork. Korean and Chinese laborers, largely under the guidance of Japanese foremen, became remarkably efficient in handling dirt in shoulder baskets at a unit cost of two thirds that of machine excavation. Also structural steel was erected and reinforcing bars were bent and placed by native labor. Materials were handled by railroad, lighter, push car, and bull cart. Concrete placing continued through the winter of 1930–1931 in freezing weather. Buildings were rigidly designed, each to move as a unit under earthquake shock. Special precautions were taken for protection against deterioration by the moisture and acid incident to the corn refining processes. Concrete surfaces were covered with waterproof paint; reinforcing steel was deeply embedded; and exposed steel was protected with acid-resisting paint.

AT ARGO, near Chicago, is located the largest plant of the Corn Products Refining Company, which owns in addition several other plants in the United States, at Edgewater, N.J.; Pekin, Ill.; and Kansas City, Mo. The plant at Argo is equipped to grind 85,000 bushels of corn a day. For many years this company's products have been sold abroad, and to serve these foreign markets as they have developed, sales offices and branch manufacturing plants have been placed, within the past few years, in all leading European countries. The two latest plants built are in Brazil and in the Argentine, and plants have recently been purchased in Mexico and in Jugo-Slavia.

In the Orient, the Corn Products Refining Company has been doing business for approximately 20 years. Of all Oriental countries, Japan has always been a market for the largest volume of goods, and today gives promise of being an even larger consumer. In order to have direct contact with Oriental markets and to serve them as efficiently as possible, the company decided to place a plant, with a capacity of approximately 2,000 bushels a day, somewhere in the Far East.

After this preliminary decision, investigations were made, and it was found that the industrial possibilities for such a plant would be great. As a result, it was definitely decided to build a Far Eastern plant having a capacity for grinding 6,000 bushels a day, but which could be expanded by small increases and changes in the facilities originally provided to take care of 12,000 bushels a day. It is expected that this plant will supply the market in Japan and other Oriental countries.

A preliminary survey was made by both sales and engineering representatives of the Corn Products Refining Company in order to consider all phases of plant location. This survey covered the Island of Hokkaido, the mainland of Japan, the Island of Kyushu, and all of Korea as far north and west as the Manchurian border. The sites investigated were finally reduced to three —one in Hokkaido, another in Kyushu, and the third in northern Korea. Of these, Heijo, in Korea, was finally chosen. In Fig. 1, its geographic relation to the Orient is shown.

In selecting this site many factors were thoroughly investigated. Among them were the following: local labor conditions; roads, electric lines, and railroad passenger service; freight transportation both in and out of the region by rail and water; available railroad siding; electric power supplies; coal and other fuel supplies; sewage facilities; water supplies; desirable topography; and good solid soil upon which to build.

Heijo, the county seat of a large farming and mining district, has a population of approximately 120,000 people. It is situated on low, level ground on both sides of the Daido River, 35 miles inland, and at the foot of a mountain range which follows the course of the river. On high ground directly above the city stands the celebrated Botan-dai, or Peony Heights, with its gate commemorating one of the hard-fought battles of the Sino-Japanese war. The city is located approximately 165 miles north of Keijo (formerly Seoul), the largest and most important city in Korea, and approximately 100 miles southeast from Shingishu, which is the border city between Manchuria and Korea. It is an important junction point on the main line of the Chosen Government Railway which connects with the South Manchurian,

Chinese Eastern, and Trans-Siberian Railway systems, and is thus a vital part of the transportation system from Japan to all Oriental and European countries. On the Yellow Sea at the mouth of the Daido River, 35 miles west from Heijo, lies the town of Chinnampo with harbor facilities and frequent service by several steamship lines. Efficient rail and water transportation is available between these two points.

The climate in this section of Korea is exceptionally good, as there is an average of nearly 200 pleasant days each year. The average yearly rainfall is 37 in., and the period of concentrated rainfall, known as the flood season, comes during the latter part of July and August. Severe cold weather and freezing start approximately the middle of December and continue until the first or middle of March. The river is ordinarily frozen over for from three to four months, although in average years the snowfall is rather light.

SECTION OF THE DIKE PARTIALLY REMOVED IN ERECTION OF BUILDING NO. 24, DAIDO RIVER IN BACKGROUND
Bull Carts Used in Handling Aggregate

The site selected in Heijo consists of a large level area of approximately 68 acres, located in the suburb of Daidoko. This site, shown in Fig. 2, is bordered on the north by the Daido River, on the east by the Chosen Government Railway and Daidoko Station, and on the south and west by a creek flowing into the river farther down. Located approximately two miles from the center of the city, on the main highway leading to the south, it is in the center of a district which will later be developed as the industrial and manufacturing section of Heijo.

ENGINEERING CONDITIONS FAVORABLE

As a part of the preliminary engineering work, climatological conditions were carefully studied, particularly in reference to floods and flood-protection methods. Data were furnished by the Chosen Government Meteorological Observatory, located in Heijo, and by the Chosen Government Railway. Floods in this district are frequent and severe, due to the lack of vegetation on adjacent hills, which causes the rapid rise of the river. The maximum rise on record is about 31 ft. This investigation led to the construction of an earth dike to protect the plant.

Chosen has been comparatively free from earthquakes for 300 years or more, although at earlier dates they were apparently frequent and severe. The Chosen Government Observatory at Jinsen, near Keijo, furnished all available seismic records, and a study of these indicated that at the present time there is little likelihood of destructive earthquakes. This is the consensus of opinion of the inhabitants, and practically all building work is done without considering the possibility of a severe earthquake. There are, however, occasional earthquakes of small intensity which occur more or less regularly year after year. Taking into account all the information available on the subject, it was decided to design all the buildings of the plant to resist earthquake action.

To determine foundation conditions, 26 core borings were taken over the whole site. An extremely hard gravel bed was found at a maximum depth of 42 ft. below the surface. By digging test pits in other locations this hard gravel stratum was found to be very close to the surface and in one place it appeared as an outcrop. This gravel stratum proved to be excellent for building foundations, although soil bearing tests showed all overlying

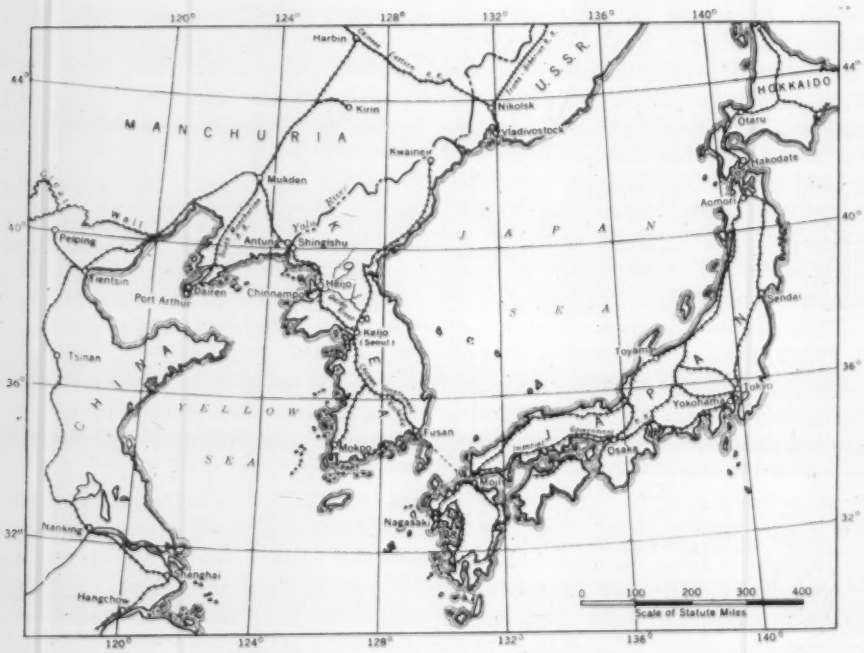
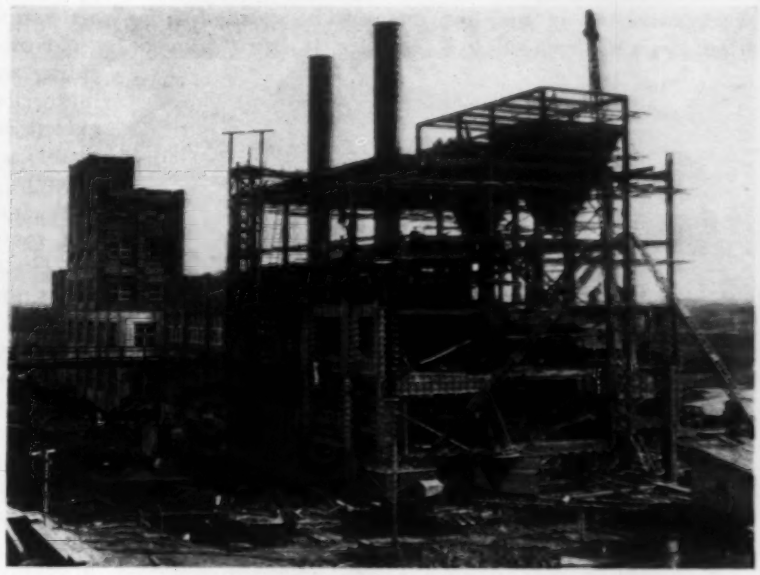


FIG. 1. MAP OF KOREA AND JAPAN
Showing the Location of the Heijo Corn Products Plant in Relation to the Orient

material to be unsuitable. A contour map, Fig. 3, was made of the surface of this stratum, and the foundations were designed accordingly. Fortunately it was possible to locate the buildings on the site so that spread footings or mat foundations could rest directly on the gravel near the surface and without piling.

In making core borings, the groundwater level during the months of October and November was found at an average elevation of about 20 ft. below the surface. To determine available groundwater supply, a well 4 ft. in diameter was dug and tests were made. Samples of the water were found suitable for drinking purposes and for factory use. In the following summer this same well was again tested and found satisfactory. The data obtained were used in designing the works for the supply of water to the plant.



CONSTRUCTION OF BOILER HOUSE NO. 23 AND ENGINE ROOM NO. 19
Use of Modern American Equipment and Korean Labor

BUILDINGS DESIGNED IN THE UNITED STATES

Complete architectural and engineering drawings for all the buildings, together with specifications, were made by the Corn Products Refining Company's Engineering Section in Chicago. The general architectural designs for the buildings follow the principles which have been developed in the other plants built by this company. Each building is designed from the standpoint of utility and houses some particular operation, equipment, or apparatus. Many tanks, hoppers, and bins are included in the equipment, and there are innumerable sleeves and other openings through walls and floors for the piping.

The framework of each building was designed to resist earthquakes by using a coefficient of 0.10 *G*, which is the minimum requirement stipulated in the Tokyo Building Code as revised after the great earthquake of 1923. Such design requirements for the horizontal movement of buildings were met by various types of bracing—by X-bracing wherever possible, and by haunches on girders and beams. Also column sections were enlarged, with the radius of gyration about both axes nearly equal, and other provisions were made as individual cases required. The foundations are so constructed that if an earthquake acts upon the buildings, each one will move as a unit.

In specifying the materials to be used in the construction of each building, consideration was given to all factors affecting this particular unit of the plant. Because of earthquake exposure, all buildings have steel frames and reinforced concrete floors and walls. Some smaller units are made entirely of reinforced concrete. On many of the buildings wooden roofs are used because of acid and moisture conditions with n the structure, and for the same reason wood sash is used throughout. In Building No. 9, practically the entire floor construction and tables for handling starch liquors were made of wood and supported on wooden girders to combat moisture and acid conditions. Because of the presence of starch dust in Building No. 29 and of powdered coal in Building No. 23, dust collectors were installed to prevent explosions. These buildings were especially designed to minimize the intensity of explosions, and explosion-proof hardware was used for the sash. The roofs of both buildings are of wood.

As a special precaution, all reinforcing steel was embedded in the concrete more than the usual depth in order that acid action on the concrete might not cause exposure and consequent rusting. Steel and concrete

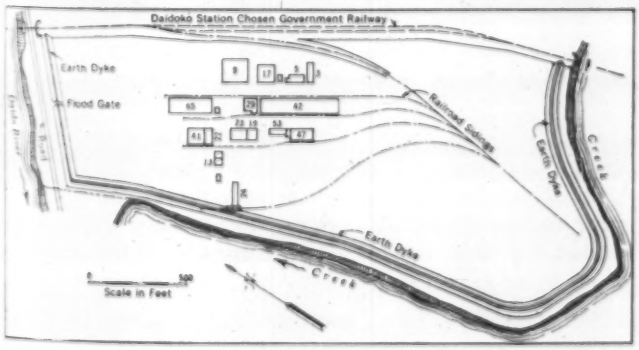


FIG. 2. PLOT PLAN OF NIPPON CORN PRODUCTS REFINING FACTORY

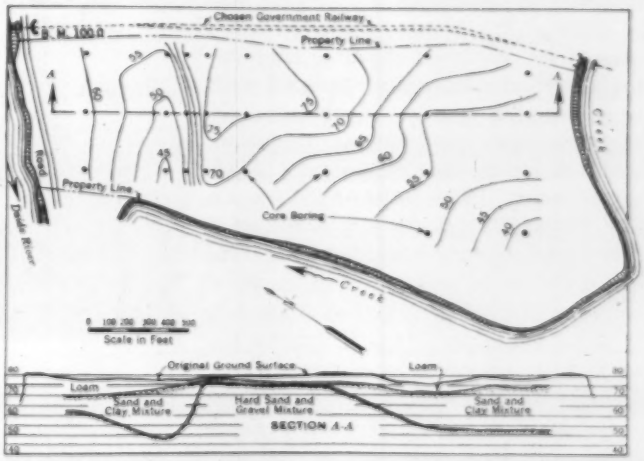
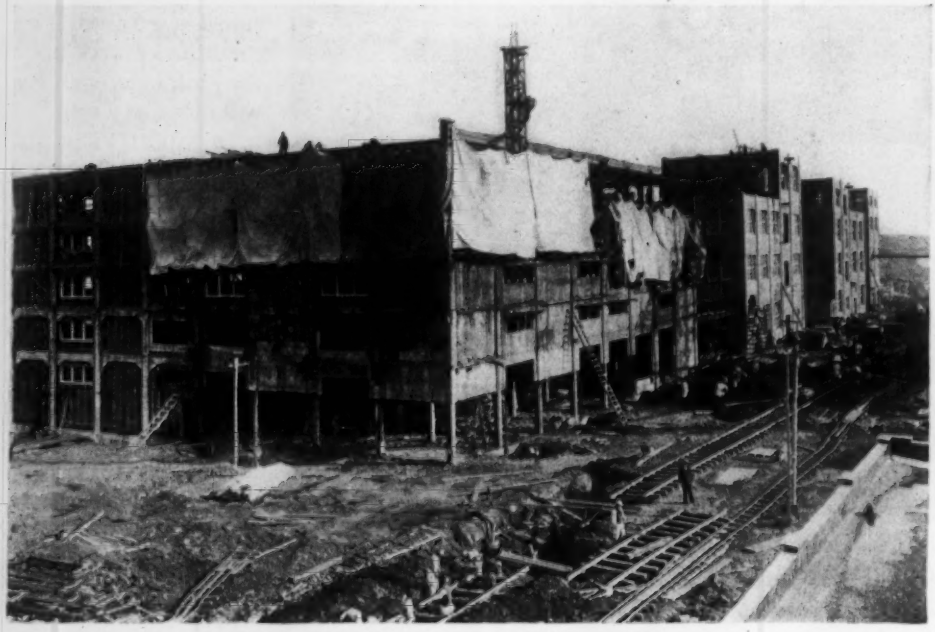


FIG. 3. CONTOUR MAP OF UNDERLYING HARD GRAVEL STRATUM

surfaces, when exposed to acid conditions, were painted with special acid-resisting paint.

NEW METHODS OF CONSTRUCTION FOR KOREA

Preliminary construction work was started on the site in October 1929. This work consisted of building an earth dike about one mile long around three sides of the property, and completing the fill for the railroad siding from the main line into the plant. The railroad embankment forms a natural dike along the fourth side of the plant. The dike that was built averaged 15 ft. in height above the general property level, and it was constructed by stripping the surface where the fill was to be made. Earth was excavated entirely by hand labor, carried in *chigis*, or shoulder baskets, deposited in place, and tamped with large wooden mauls. Approximately 750 men were used for this operation, and the entire dike contained 110,000 yd. of earth. The finished dike has a 6-ft. top width and side slopes of 2 on 1. The entire surface is sodded with *shiba* grass, the sods being pinned in place with wooden pegs. The top of the dike is at an elevation 3 ft. 4 in. above the maximum recorded flood stage of the river.



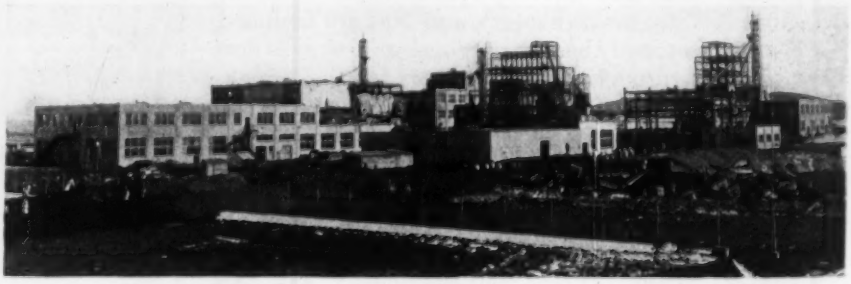
TEMPORARY ENCLOSURES FOR WINTER WORK
Starch Refining and Gluten Building No. 9

Foundation tests and other preliminary work were done during the winter and completed early in the spring. Actual construction on the railroad siding and on six of the buildings began in April 1930. From that time on, work has been carried forward at full speed, buildings having been put up as plans were completed. The entire project was finished in May 1931.

The plant used for construction resembled those ordinarily required for similar jobs on steel and reinforced concrete in the United States. There were, of course, some variations because of local conditions. No extra plant or equipment was provided for speed because the progress schedule could not be determined at that time. Although the usual methods of construction were followed, they seemed very unusual to the inhabitants of Heijo.

The railroad siding was completed first, the materials for it being moved by narrow-gage track. After the siding was finished most of the materials were delivered by rail, except sand, gravel, reinforcing steel, and rails, which were brought in on lighters. Forms were built beside the track at the south end of the property and distributed by hand cars on the siding. All reinforcing steel was cut and bent on the site, while the structural steel was unloaded and distributed with caterpillar crane and erected with two traveling stiff-leg derricks. In general, this job was executed with considerably less machinery and considerably more man power than is usual in construction operations.

In Heijo, as in all of Korea, building materials are very scarce. However, such material as was available was purchased locally. Much of this was brought to the site of the work by bull carts. The main items in materials and equipment were purchased in Japan and shipped to the job by way of Chinnampo, whence they were delivered by railroad or lighter. About 1,000 tons of intermediate grade reinforcing steel were needed. It had to be made by special rolling as this grade of steel has seldom been used in the Orient. About 3,000 tons of the structural steel were manufactured by the Imperial Steel Works in Japan and fabricated by the Tokyo Bridge Company. Form lumber was supplied from the Yalu River forests about 100 miles from the job and machined at Shingishu, where planers were specially installed for this work. Approximately 27,000 cu. yd. of sand and gravel were dug by hand labor from the river.



PROVISION MADE FOR WINTER CONDITIONS
View from Top of Dike at Northwest Corner of Property

LOCAL LABOR SATISFACTORY

Labor throughout the job varied from the employment of a few men for the preliminary work to a maximum of

about 1,800 men at the height of construction, this number being gradually reduced toward the end. The majority of the workmen used were Koreans, native to the Heijo section, or from outlying districts. A few Chinese were employed on the project, and the remainder of the laborers, including the most skilled workmen, were Japanese. Sub-foremen and foreman were developed from the workers in the course of construction, but the supervising foremen were from the Builders Organization in Tokyo.

It was found by comparisons made during the work that, for items of excavation, costs for common labor were approximately two thirds of those for the same work accomplished by mechanical means. This was due to the low cost of labor and the remarkable efficiency of the Korean people in handling dirt. By numerous comparisons it was also found that labor costs on various items of construction work varied from one half to three quarters of the cost for similar items in America.

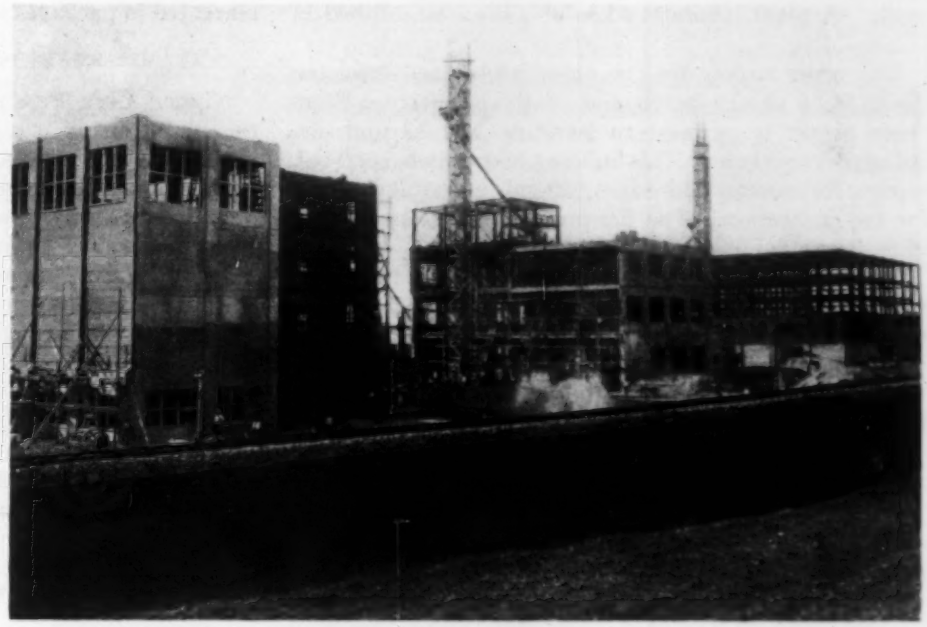
Construction methods and details were well known to the few general foremen and skilled workmen engaged on the project. The majority of the workers, however, did not understand these methods and much time was spent in teaching them to work in accordance with a prearranged plan. But it was found that they were ready and anxious to learn new methods and that they grasped them rather quickly, so the progress of the work kept pace with the plans for it. All field engineering, tests, investigations, and construction work were handled by the Tokyo branch office of the H. K. Ferguson Company.

DIKE AND FLOOD GATE ALONG DAIDO RIVER UNDER CONSTRUCTION
Two on One Slopes Sodded with Shiba Grass

After November 1, 1930, unusually severe winter conditions prevailed at the site, and it was thought at one time that it would be necessary to suspend operations until warmer weather. In fact, construction had never before been conducted through the winter in Heijo. It was found, however, by re-scheduling some operations and taking advantage of all changes in the weather, that work could be continued with a partially reduced force. Concrete placing, steel erection, carpentry, both inside and outside the buildings, and other miscellaneous items constituted this winter work.

TEMPERATURE SEQUENCE ESTABLISHED

Temperature records kept for the job indicated that during cold weather a period of four cold days was ordinarily followed by two warm days, and that this sequence kept repeating itself. In accordance with these sequences, 10,000 cu. yd. of concrete were placed between October 31 and April 7. Coke burned in salamanders furnished heat in the buildings, and sand, gravel, and water heaters were provided. All temporary enclosures were made with canvas on wood frames.



VIEW WEST FROM MAIN LINE OF THE CHOSEN GOVERNMENT RAILROAD
Buildings Nos. 3, 5, 17, and 9

Winter construction, of course, increased costs to some extent on many items, but it enabled the work to be completed considerably sooner than was anticipated. Labor under these conditions was found to be approximately 90 per cent efficient.

Since the process of manufacture consists largely of the distribution of materials in liquid form, pumps and piping constitute a large part of the equipment provided. There is no city fire protection at the plant site, so pumps were required for fire protection. Additional pumps were installed to dispose of rainfall during flood periods when the dike gate is closed. Many items of equipment in this plant are entirely new developments and are being used for the first time in production.

MACHINERY, EQUIPMENT, AND PROCESSES

The boiler house and engine room, which furnish the power and steam for operating the plant, are completely equipped with the most modern machinery. Power is furnished by two 500-hp. boilers, that have powdered fuel equipment and a separate coal drier. These operate

at a 400-lb. pressure and with 100-deg. super-heat. There is one 1,500-kw. 60-cycle 3-phase turbo-generator set, bleeder type, operating at 440 volts.

Each of the other buildings throughout the plant is equipped with special machinery for the various operations to be carried on in that particular structure. Shops have been installed in Building No. 65 for the maintenance of electrical, mechanical, piping, and wood work. A plant laboratory has also been established in this building.

The water supply for the plant is obtained from ten 65-ft. wells at the north end of the property. From these, water is pumped to Building No. 13 and distributed from there. This building houses two 5,000-gal. pumps for sewage and one 1,000-gal. centrifugal pump for fire protection. The fire-protection system consists of underground lines and hydrants.

Throughout the plant piping is a very large item. As soon as work on the buildings had begun, the owner started installing pipes, and this work followed the progress of the job. Cast-iron pipe was largely used throughout. Electrical and mechanical work was also installed in the same manner.

MUCH EQUIPMENT PURCHASED LOCALLY

More than one third of all the equipment housed in the plant was purchased locally, but most of the special machinery was bought in America and Europe and shipped to the site. Four vacuum driers from Warren, Pa., weighing 35 tons each, constituted the largest load ever handled at the port of Chinnampo and caused numerous difficulties because of the lack of adequate handling equipment.

A new development in manufacturing peculiar to this plant is that corn is flushed from Building No. 42 to wood-stave steeping tanks, 16 ft. in diameter and 26 ft. high, in Building No. 3. From these tanks it goes to the mill, Building No. 5, where the starch is separated from the chaff and germ. The germ is dried in steam driers in Building No. 17 and the oil extracted by expellers. Chaff is also dried in Building No. 17 and packed as cattle food.

Starch liquors are tabled in Building No. 9, where they are refined and the gluten is removed. Clear starch is washed in Building No. 29 and dried in vacuum driers, a portion then being pumped in a liquid state to Building No. 53 for conversion to glucose.

Among the principal products manufactured by the new plant are the following: starch in various forms, industrial corn sugar, corn syrup, edible oils, and cattle food. These products are consumed largely by the following industries: textile, artificial silk, paper manufacturing, tanning, and confectionery. Starch is also marketed in packages and in bulk.

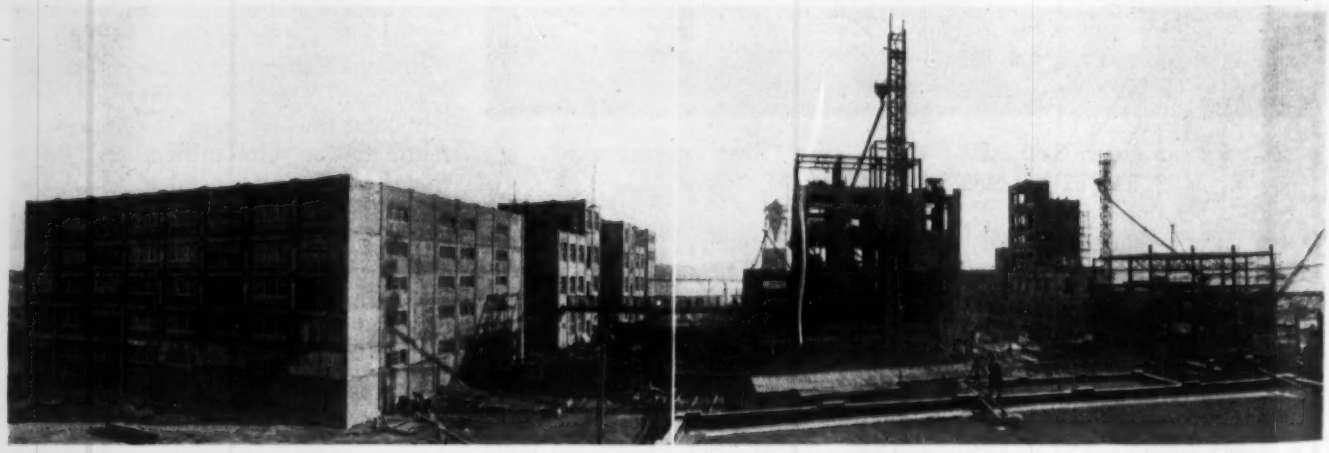
SUBSIDIARY COMPANY TO OPERATE NEW PLANT

Nippon Corn Products Kabushiki Kaisha, operating this new plant, is a separate company financed with an authorized capital of 10,000,000 yen, which will be held by the home company in New York and which will be participated in by local interests. The location of this plant in Korea is fortunate in that it introduces new raw materials not at present produced in the country. It will therefore not crowd present industries. It gives Japan new products to work with and provides Korea with a new industry which will give employment directly and indirectly to many people.

Manufacturing supplies will be drawn largely from Manchuria in the winter and from the Argentine in the summer. There is not much local corn because land is not available in Korea for economic production. Coal will be supplied from local mines near the plant or possibly from Manchuria. The plant will be equipped to operate on either corn or *kao-liang* (milo or kafir corn).

PERSONNEL LARGELY FROM LOCAL SOURCES

It will have six men from other plants as a nucleus to start, and the balance of the personnel will be made up from local sources. The company is now building five houses for its staff on elevated ground overlooking the Daido River near the new plant, and it has made plans for baseball, tennis, and other athletic features to be developed for its employees at a later date, on land within the manufacturing compound. The new plant represents the most modern aspects of layout and construction. Embodying all improvements in machinery and equipment for efficient corn refining, it is the second largest plant of its kind outside the United States. The one that is larger is operated by the same company in Germany.



NIPPON CORN PRODUCTS KABUSHIKI KAISHA FROM ROOF OF BUILDING NO. 65
From Left to Right, Buildings Nos. 9, 17, 5, 3, 29, and 42, 47, 19, and 23

HINTS THAT HELP

Today's Expedient—Tomorrow's Rule

The minutiae of everyday experience comprise a store of knowledge upon which we depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from young and old alike, should afford general pleasure not unmixed with profit.

Design of Pavement Signs for Traffic Control

By C. J. TILDEN

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
PRESIDENT, ENO FOUNDATION FOR HIGHWAY TRAFFIC REGULATION, INC., NEW HAVEN, CONN.

WHENEVER it is possible to put signs for the warning or caution of motorists on the pavement, there are certain advantages in doing so. The motorist can read them while at the same time keeping his eyes and

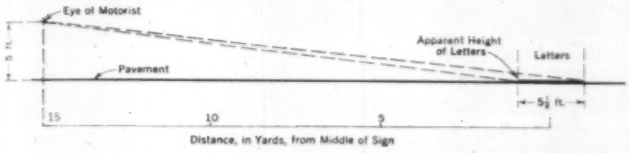


FIG. 1. APPARENT AND ACTUAL HEIGHT OF PAVEMENT LETTERING

attention to the front. The word or phrase may be put exactly where needed, which is not always possible when a sign post is set at the side of the road.

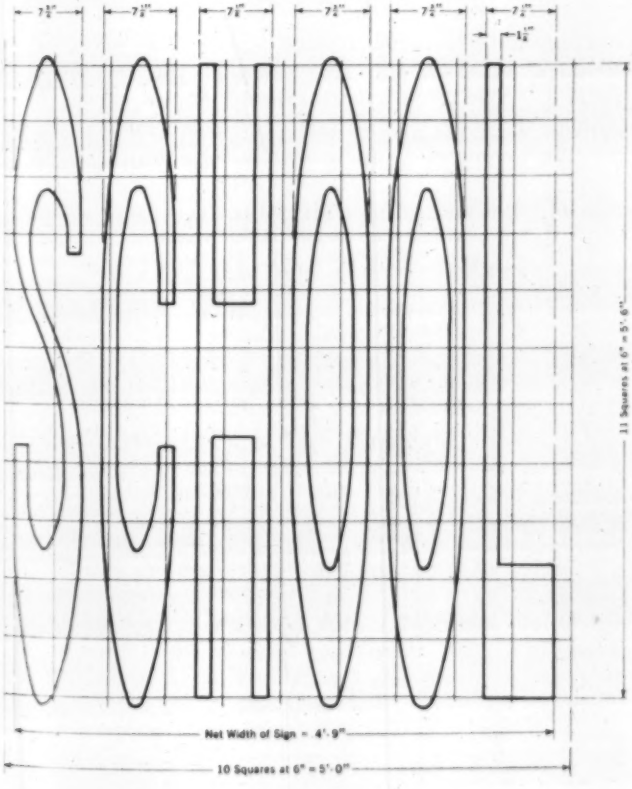


FIG. 2. DESIGN OF ELONGATED PAVEMENT LETTERS

If ordinary letters are used, approximately square or even with a height somewhat greater than their width, they are generally not readable until the motorist is practically on top of them. At a distance of 6 or 8 yd. they are so foreshortened as to be illegible. However, by stringing them out so that their height is eight or ten times their width, they may be read from such a distance as to give the driver ample time to act on the warning. This is made clear by the diagram, Fig. 1. If the letters are 5½ ft. high and 7 in. wide, they will appear approximately square at a distance of 15 yd. and may be easily read at a much greater distance. The elongated letters and signs illustrated in Figs. 2 and 3 have been designed especially for this purpose. They have been tested in actual use and their dimensions are such as to give the best results at distances of from 20 to 40 yd. This distance is usually ample, but a motorist with normal eyesight can read such warnings still farther away. A speed of 30 miles per hour is about 15 yd. per sec.

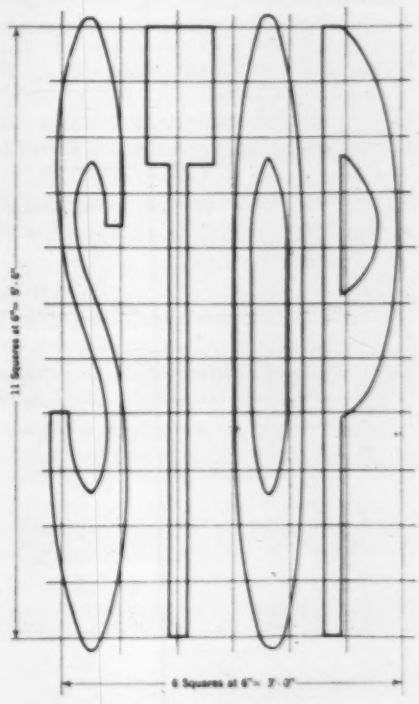


FIG. 3. PAVEMENT LETTERS FOR A "STOP" SIGN

The best way to put these letters and symbols on the pavement is by using a stencil cut from heavy manila paper. This, if carefully handled, can be used many times over. By means of the two diagrams, Figs. 2 and 3, with backgrounds of 6-in. squares, these letters can be readily drawn full size on the stencil sheet. Designs may be made for other words, such as "right," "slow," "left," "care." If the sign is needed in only one place it may be drawn directly on the pavement by first laying off the 6-in. squares with chalk lines, thereby saving the labor of making a stencil. If more than one sign is required, however, a saving in both time and money will be effected by cutting the stencil first.

The best quality of white paint obtainable should be used. The cost of the material is only a fraction of the labor cost, especially if the signs must be repainted two or

three times during the season, as is generally necessary under normal conditions of traffic and weather. Any attempt to save by the use of inferior paint will be found very poor economy.

Determination of Spherical Excess with a Calculating Machine

By H. FRED PETERSON
ASSOCIATE MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
SOUTH PASADENA, CALIF.

IN DETERMINING the geodetic coordinates of triangulation stations, much time is ordinarily consumed in computing the spherical excess of the triangle involved. This time can be materially reduced by deserting logarithms in favor of the calculating machine. By this means the process is reduced to the multiplication of one number by another and the division of the product by a third factor obtained from a table. The answer in the calculating machine is the spherical excess per angle.

As the spherical excess deals with values relatively minute when compared to the other factors in the computation of the triangle, the figures to the right of the decimal point in the length of the sides can be omitted, as can also the seconds in the angles between the sides.

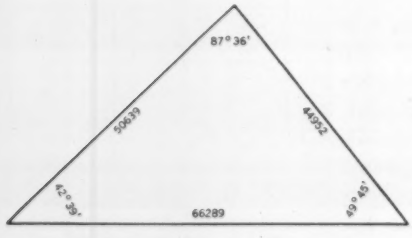


FIG. 1. EXAMPLE FOR COMPUTATION OF SPHERICAL EXCESS

For example, consider the triangle in Fig. 1. Multiply the lengths of two sides of the triangle, and divide this product by the factor taken from Table I, as follows:

$$\frac{44{,}952 \times 66{,}289}{16{,}650{,}750{,}000} = 0.179 \text{ sec.} = \text{spherical excess per angle.}$$

The factor 16,650,750,000 is obtained by interpolating between values for 49 deg. 30 min. and 50 deg. 00 min. and adding the five ciphers which have been omitted in the table. Such a table can be easily computed for any range of latitudes desired. The one given here as an example is for a mean latitude of 35°, but it can be used for any latitude between 30° and 38°, to give a value for the spherical excess which will be correct to one thousandth of a second.

This computation may be checked by the old method as shown on page 293 of U.S. Geological Survey Bulletin No. 650. The problem then is worked out as follows:

Spherical excess in seconds = $a \times b \times \sin C \times m$

where a and b = the two sides expressed in meters
C = the included angle = 49 deg. 45 min.
m = a factor in the table on page 294 of Bulletin No. 650
a = 44,952 ft. = 13,701 m.
b = 66,289 ft. = 20,205 m.
log a = 4.13675
log b = 4.30546
Log Sin C = 9.88266
Log m = 1.40501 (taken for latitude of 35°)
Then log excess = 9.72988
Total spherical excess = 0.537 sec.
Spherical excess per angle = 0.179 sec.

METHOD OF COMPUTING TABLES

The method used in computing Table I and similar tables is as follows:

Total spherical excess in seconds = $a \times b \times \text{Sin } C \times m$, where a and b are in meters

Let f = factor 0.3048006 used in converting meters to feet

Assume a latitude of 35°

Log m = 1.40501
$m = 2.541 \times 10^{-9}$
$f^2 = 9.29 \times 10^{-2}$
$m \times f^2 = 23.607 \times 10^{-11}$

The table is designed to obtain the spherical excess for one angle instead of three by taking the following steps:

$$\frac{3}{23.607 \times 10^{-11}} = 12{,}708{,}100{,}000$$

This factor is to be divided by the sine of the angle included between the two sides in the formation of Table I. The table is made only for angles varying from 30 deg. to 60 deg, as all but very exceptional cases will provide a convenient angle within these limits.

TABLE I. FOR DETERMINING SPHERICAL EXCESS FOR ONE ANGLE, FOR LATITUDES FROM 30° TO 38°

Each Factor Is to Be Followed by Five Ciphers

Angle in Deg.	Factor	Angle in Deg.	Factor
30	254,162	45	179,720
	0.387		8,172
31	246,741	46	6,663
	3.218		5,194
32	239,812	47	3,761
	6,518		2,365
33	3,331	48	1,004
	0,245		169,678
34	227,258	49	8,384
	4,364		7,123
35	1,559	50	5,892
	218,840		4,693
36	6,203	51	3,523
	3.645		2,381
37	1,163	52	1,268
	208,753		0,182
38	6,414	53	159,123
	4,141		8,089
39	1,934	54	7,081
	199,788		6,097
40	7,703	55	5,137
	5,675		4,201
41	3,704	56	3,287
	1,786		2,396
42	189,920	57	1,527
	8,104		0,679
43	6,336	58	149,851
	4,616		9,044
44	2,940	59	8,257
	1,309		7,489
		60	6,741

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

More Clearance Under Drawbridges

TO THE EDITOR: The War Department hearings on bridge clearances, now being held in various parts of the United States, emphasize the attention at present centering upon the relationship between land and water transportation.

In behalf of the Board of Commerce and Navigation of New Jersey, I would like to bring to the attention of the members of the Society a resolution which the board passed on March 16, 1931, as follows:

"WHEREAS, Travel on landways and on waterways is rapidly increasing in New Jersey; and

"WHEREAS, Low drawbridges offer at best a grade crossing,

"*Therefore, be it resolved*, That in the promotion of grade crossing elimination, it is the opinion of the Board of Commerce and Navigation that it would be advisable to require hereafter at least 15 ft. clear headroom above normal high water for every bridge to be built over navigable water, or over water which may, in the near future, be made navigable, and to require at least 35 ft. clear headroom above normal high water, for every bridge to be built over water carrying commerce in vessels of 10-ft. draft or more, or over water which may in the near future be used for commerce of 10-ft. draft importance."

While the Board of Commerce and Navigation of New Jersey is keenly alive to the importance of land traffic, its particular function is to safeguard waterways and water traffic. With the problems of land traffic in mind, the board is constantly urging proponents of bridges over navigable waterways to put them high enough for boats to pass beneath without interrupting land traffic. Also, I may say that the present board stands ready to support legislation requiring specific authority for opening drawbridges that have been built high enough above the water to permit reasonably designed vessels to pass under.

AUGUSTUS SMITH, M. Am. Soc. C.E.
Commissioner of Board of Commerce and Navigation of New Jersey

Jersey City, N.J.
September 25, 1931

A Latin-American Engineering and Construction Enterprise

TO THE EDITOR: May I use your columns to place before the engineering profession a plan that I believe is sound in principle and which, it is my hope, would advance our profession both at home and abroad?

Latin America, our neighbor on the south, has vast potential resources and business possibilities, but it has little money for desired improvements. I believe, therefore, that it would be advantageous to form an incorporated body to serve as a Latin-American Engineering-Contracting-Financing Syndicate. The function of this organization would be to make a systematic and scientific effort to develop all of Latin America.

In essence, the program would consist of the selection of economically sound construction enterprises, and of the planning, financing, and actual development of these. The proposed syndicate would consist of, say, 15 engineers of established ability, each a specialist in his line; some 30 or 40 contractors of proven skill and efficiency, each also a specialist in his line; and a sufficiently broad grouping of financial interests to insure an adequate supply of funds for any sound undertaking agreed upon.

A first step would be to send three lecturers to appear before civic bodies throughout Latin America, in order to make known to the inhabitants the caliber of the syndicate, its method of operation, and its ethical character. Unless this affiliation were highly ethical it would be more harmful than helpful.

The syndicate should be the means of promoting profitable business enterprises, the development of latent resources, and the continuance of friendly relations with our less favored neighbors.

Is there any reason why such an arrangement should not be advantageous to all concerned? It is a matter for the profession to decide—hence my first mention of it in the columns of a Society publication. The details are already well worked out. Does the profession endorse the idea as one worthy of being developed and carried through by the civil engineers of the country?

I hope that this suggestion will be thoroughly discussed in your columns by engineers of high standing, who are interested in foreign affairs, in the general welfare of our country and of Latin America, and in the extrication of our national business from the "slough of despond" from which it has been trying to free itself for the past two years. If the consensus of opinion thus obtained is favorable, I shall undertake to bring the matter systematically to the attention of those who either are, or ought to be, interested in its materialization.

J. A. L. WADDELL, M. Am. Soc. C.E.
Waddell and Hardesty, Consulting Engineers

New York, N.Y.
September 15, 1931

Research Important for Engineering Development

TO THE EDITOR: In his paper on "Models Predict Flow Through Structures," in the September issue of CIVIL ENGINEERING, Mr. Stevens referred to the part which the universities may play in the development of hydraulics, and stated that their function is primarily one of teaching and not of research. This view implies a basic fallacy—that is, that teaching and research can be permanently separated. Research is merely a quest for new facts, and the teacher who fails to continue this quest is usually uninspiring, and his lectures soon become obsolete. The engineering colleges have the duty of sending out graduates who are trained beyond the present status of the profession, but they cannot do this unless their faculties are engaged in that speculation and experimentation which we call research. Experimentation is by no means a necessary part of research, but it is a useful check on theoretical deductions.

The fact that the hydraulic laboratories in American universities have not made greater contributions to our knowledge of hydraulics is the result of a lack of interest in them on the part of the engineering profession rather than any lack of effort on their part. In general, the laboratories have not been asked to cooperate and, when they offered assistance, their offer was usually considered somewhat presumptuous. At the state universities at least, lack of equipment or personnel is no real obstacle to research because funds will be made available for such laboratory work as soon as the authorities are convinced that it is desired by a considerable body of engineers and will be of benefit to the institution and the state. The University of California has instituted a modest program of research in hydraulics, which we hope to expand to a degree commensurate with the magnitude of the hydraulic problems of the state. However, this expansion will be impossible unless there is an insistent demand for such facilities.

Models of hydraulic structures, if improperly handled, may lead to very erroneous conclusions. They are not foolproof, and each model must be carefully designed. To make a model it is not sufficient to build a scale reproduction of a river, harbor, or dam and run water over it, but the model should be so designed that the results obtained can be safely transferred to the full scale by means of some predetermined model law. As an example of the danger of using these models, I may cite a model test of a dam containing a logway, which was made at the Royal College of Engineering in Stockholm. Briefly, the problem was to so locate a dike that the surface currents would carry the logs toward the inlet to the logway. The model dike was made of putty, and small sticks were used to represent the logs. The proposed dike was found to act satisfactorily, but it was suspected that the slight amount of oil which came out of the putty was affecting the action. Another dike was constructed of plaster of paris, and the reaction was entirely different. A less careful or less skilled experimenter might not have noted this source of error and recommended a design which would have been improper.

Some engineers distrust small models, and their attitude is not entirely unjustifiable. The number of checks on the agreement between model and prototype—particularly on distorted models and models involving the movement of debris—is not sufficiently large. After a structure is built, it may be years before the conditions tested in the model will occur in nature and, then, the necessary measurements for checking the theory are seldom made. The data available indicate a good agreement between model and prototype for undistorted and slightly distorted models.

Experiments were made as part of the investigation of the so-called "salt water barrier" in San Francisco Bay. The problem studied was that of the motion of salt water when placed in contact with fresh water. Such action occurs during the passage of a ship through a lock connecting the ocean with a fresh-water pool. The U.S. District Engineer at San Francisco requested that the university make the tests necessary to establish the model law so that a large model could be constructed. Theoretical investigations indicated that the simplified model law is

$$\frac{L}{D^{2.5}\sqrt{S}} = \text{constant}$$

where $S = (S_1 - S_2)$ = difference in specific gravities on the two sides of a gate

L = any characteristic horizontal dimension

D = characteristic vertical dimension

This conclusion was substantiated by the experimental data.

MORROUGH P. O'BRIEN, Assoc. M. Am. Soc. C.E.
Associate Professor of Mechanical Engineering
University of California
Berkeley, Calif.
September 28, 1931

Research in Field of Reinforced Concrete

TO THE EDITOR: It has been suggested in the articles and discussions on reinforced concrete in recent issues of CIVIL ENGINEERING that a new formula for reinforced concrete columns is needed and that the field is a fruitful one for investigation. As Chairman of Committee 105 of the American Concrete Institute, I am glad of this opportunity to state that the committee is already considering this problem and believes that it has experimental information which will be of great value in reaching a solution. Progress reports of the experimental work are given in the *Journal of the American Concrete Institute* for February and March 1931, and in *Proceedings of the American Concrete Institute* for 1931, pages 675 to 835. In the investigation made by Committee 105, columns were tested at 56 days. These had not been previously loaded, so the question of plastic flow of the concrete was not involved. Another group of similar columns was tested at 14 months without having been previously loaded, and a third group was tested at 14 months after having been under working load for one year.

The results of the 56-day tests at Lehigh University are summarized in the report (*Journal of the American Concrete Institute* for February 1931, page 730) as follows: "The indication of the tests is that the strength of the columns having longitudinal and spiral reinforcement was made up of (1) 85 per cent of the cylinder strength times the net area of the concrete within the outer circumference of the spiral; (2) the yield-point stress of the longitudinal bars times their area; and (3) the strength added by the spiral, which amounted to about 70 per cent of the strength added by an equal amount of longitudinal reinforcement of intermediate grade steel."

In spite of the facts that the strength of the concrete had not, in all cases, increased and that shrinkage of the concrete had caused stresses in the longitudinal reinforcement as high as 11,500 lb. per sq. in., the 14-month tests of the columns which had not been loaded gave strengths which, in all cases, were greater than those for the 56-day tests. Also, all the columns which had been under working load for one year gave strengths higher than those of corresponding columns (not previously loaded) tested at 56 days, although the stress in the steel due to the combined effect of shrinkage and previous loading was as high as 47,600 lb. per sq. in.

Another series of tests is in progress to determine how much load a reinforced concrete column will carry indefinitely. A column with no spiral and 4 per cent longitudinal reinforcement, made of concrete with a strength of 3,500 lb. per sq. in., has carried for six months a load which is 80 per cent of the average strength of three similar columns tested directly to failure at an age of 56 days. As judged by the measured strains, the

stress in the reinforcement has been beyond the yield point for about 5½ months. The strain at the present time is approximately 2.5 times the yield-point strain of the steel. There is no indication that this column will fail under its present load.

These data indicate that, regardless of the modification of the stress due to the effect of shrinkage and flow and of the amount of longitudinal reinforcement, the strength of a column is made up of three elements—strength of concrete, strength of longitudinal reinforcement, and strength of spiral. Consequently any formula, stated in these terms, which is valid for early strengths, will also be valid for later strengths.

W. A. SLATER, M. Am. Soc. C.E.
Director of Fritz Engineering Laboratory

Bethlehem, Pa.
September 13, 1931

Note: This letter was approved by the American Concrete Institute and by its Committee 105, before Mr. Slater's death on October 5.

Need for National Control of Important Streams

TO THE EDITOR: The symposium on "The Columbia River—for Irrigation and Power," in the September issue of CIVIL ENGINEERING, recalls to my mind the fact that the Society has for several years had under discussion a national reclamation policy. In this connection I should like to offer again the suggestion relating to a broad policy of water conservation, which I made last January at a meeting of the American Engineering Council in Washington.

Why shouldn't the rivers which are international or interstate in character, or which are important from a navigation standpoint, be subjected to flow regulation by the Government? At any rate, the Government should work out comprehensive plans for such rivers and enforce their adoption. The flow of streams that are of interest to the state alone should be regulated by the state or in conformity with plans prepared by the state.

Why give away reservoir properties to any individual, municipality, district, or corporation? There seems to be no reason why states should not construct reservoirs and make delivery of the output of water and power at wholesale to the municipalities, districts, and corporations that are prepared to make the best possible use thereof. National and state credit would thus be called to aid in conserving the country's water resources.

C. E. GRUNSKY, Past-President, Am. Soc. C.E.
Consulting Engineer

San Francisco, Calif.
October 2, 1931

Civil Engineering Field Not Overcrowded

DEAR SIR: The letter appearing in the September issue of CIVIL ENGINEERING, entitled "Supply of Civil Engineers in Excess of Demand," seems to have been written in a moment of fear that an intelligent and capable recent graduate of some engineering school might replace the author in his particular job.

Just why should a competent man who acquires an engineering education and training and who likes the work be "diverted" into any other field? There are recent graduates in the fields of finance, production, and sales.

I also take exception to Mr. Campbell's statement that recent graduates are flooding the civil engineering field. It is my opinion that the so-called flooding is being done by the diversion of men from the fields of finance, production, and sales and from several others. Any engineer can name offhand a number of men who are holding engineering jobs although they do not have engineering education, training, or the adaptability required to advance in the profession. Entirely too many men who are not engineers are holding engineering positions because they are at the disposal of non-professional men. If all such positions were filled by men educated and trained to the profession, I have no doubt there would be ample room for all engineers.

The solution suggested by Mr. Campbell is at variance with the best interests of the profession and instead of helping it would do untold harm, both to old and new members. Give engineering jobs to engineers—and more power to the recent graduates and undergraduates of engineering schools!

ROBERT C. RATCLIFFE, Jun. Am. Soc. C.E.

Denver, Colo.
October 4, 1931

Importance of Geology in Soil Mechanics Problems

DEAR SIR: In the article, "Earth as a Basic Material of Construction," which appeared in the August issue of CIVIL ENGINEERING, Charles H. Lee states, "Another difficulty arises from the more or less haphazard variability of sedimentary formations, which often necessitates intensive sampling in order to obtain an accurate knowledge of average soil conditions."

The difficulty referred to in this quotation results from the failure to recognize that this is a geological problem which cannot be solved without a thorough understanding of geological principles and a broad practical geological experience. The study of earth from the engineering viewpoint—that is, soil mechanics—consists in the application of engineering and laboratory methods to a geological problem. Any problem having to do with the arrangement of earth in the ground is primarily a geological one and cannot be adequately solved without a thorough understanding of the geology of the case, which is best obtained by cooperation with a geologist who has had practical experience in such matters.

In the type of problem outlined by Mr. Lee a practical geologist can often forecast conditions for some distance from the point of observation and can determine which strata are the critical ones that should be sampled. In this way, delay and excessive cost can be avoided. Sedimentary formations are deposited in accordance with definite principles, and with an understanding of these principles it is often possible to interpret what otherwise appears to be a haphazard variability.

The greatest progress in the field of soil mechanics can be made by the cooperation of the engineer, or the specialist in soil mechanics, and the geologist.

IRVING B. CROSBY, Affiliate Am. Soc. C.E.
Consulting Geologist

Boston, Mass.
October 10, 1931

Should Engineers Practice Architecture?

DEAR SIR: The comment, in the July issue of CIVIL ENGINEERING by Morris Kampf, entitled "Shall Civil Engineers Lose the Right to Design Buildings," is very interesting. The inclusiveness of "engineers' rights," however, is such that the architectural profession tends to be duplicated. The reader is also left with the impression that the architects are attempting to supplant or curb the engineers. This is rather an exaggeration since, to the general public, building operations properly fall within the province of architecture. The structural and other engineers are rather assistants to the architects in the same sense that they are assistants to each other. The structural engineer would be seriously handicapped without the aid of chemical and metallurgical engineers in the production of modern structural materials. The dispute between the engineers and architects in New York State is not a compliment to either profession and it may bring them both into disrepute.

Architects have conceded that structural engineers have much in common with their profession and would not object to their designing certain buildings in their entirety. The Illinois Structural Engineering Act specifies the buildings which structural engineers may design in their entirety. The scholastic training of engineers does not include all the subjects covered in architectural courses, and it would be an injustice to the uninformed public to allow engineers the legal right to engage in work for which they are not trained. The architectural courses, on the other hand, include the aspects of engineering which pertain to building. Engineers sometimes have the notion that architects are wholly "engaged with charcoal drawings, with wash drawings, and with plaster models" but this attitude only reveals an ignorance of the architect's function. The same engineers would resent any statement that they only manipulate slide rules, add long columns of figures, and pick steel beams from handbooks.

The architect is the chief executive who coordinates the work of many specialists in the building field. The general scheme is prepared by the architect, and it is for the specialists, of whom the engineer is one, to give the services which they can best render. The Building Department of New York City recognizes this fact and employs engineers to examine the structural and other engineering features shown on building drawings submitted by architects. This department is concerned only with public safety. Such intangible features as beauty, good planning, and the logical use of materials are entirely outside its province. The commissions for large bridges and other important engineering structures have recognized the ability of architects to combine the beautiful with the practical by retaining them as consultants.

Complaint has frequently been made by engineers that their former rights of designing buildings in their entirety in New York have been taken away by "discriminatory legislation" alleged to have been sponsored by architects. The so-called former rights seem rather to be a case of usurping the architect's field, due to the looseness of the Tenement House Law of New York. The following quotation is taken from Article 6, Section 120, of this law: "the owner, or his agent or architect shall submit to the department charged with the enforcement of this chapter a detailed statement in writing verified by the affidavit of the . . . ." The word "agent" is alleged to have included almost anyone who could persuade a prospective client that his services were adequate. The engineers succeeded in securing a number of commissions to prepare plans for buildings, but the final results, while structurally safe, were frequently unattractive. The same injustice that engineers complain of can also be protested by contractors and others who have represented themselves as capable of rendering architectural service. The recent Multiple Dwelling Law in New York removed the ambiguity which existed in the past by stating definitely who may act as the agent. The architects are not attempting to represent themselves as engineers so, after sober thought, the engineers should not encroach on the architectural field.

CARL E. PAULSEN, Assoc. M. Am. Soc. C.E.
Structural Engineer

Albany, N.Y.
September 6, 1931

No Need for Present Irrigation Development

TO THE EDITOR: I was greatly interested in the symposium on irrigation in the September issue of CIVIL ENGINEERING. However, these articles raise in my mind the question as to whether we are forcing developments far beyond the present needs of the country. We now have much more arable land than is needed by our population of 120 million, as is evidenced by the fact that wheat is selling for 40 cents a bushel, cotton for 5 cents a pound, and fruit, in the East, is not worth the cost of picking. Good farms sell for one half or one quarter of their value several years ago, if they can be sold at all. Yet we continue to develop and add new lands.

Would it not be wise to postpone these developments to the time when our population shall be much larger—say, 200 million or more? I understand that the arable land of the United States will support only 200 million people "on our present scale of living." Our continental area consists of about 3,000,000 sq. miles. Compare these figures with China's 400 millions living in about the same area (which includes Mongolia) and with India's 300 millions living in an area of a little under 2,000,000 sq. miles.

Is it not time for the engineering profession to take stock of the situation and lend a hand to the economist and others who up to now, it would seem, have only been fumbling the problem that confronts us and the whole world? The prosperity of the United States is largely based on engineering. Russia is swinging into line. Eventually methods of living and the support of increasing populations will depend, for the most part, on engineering. Or, shall Mahatma Ghandi's contention that it is better to do away with all machinery and give the people a chance to work be realized?

In any event, it is time that the engineering profession awoke to a realization of the fact that its work in the future will be vastly more important than it is today. This is true in spite of the fact that recent achievements in science and engineering have far outstripped the amazing imaginings of Jules Vernes and similar writers.

MORTIMER E. COOLEY, M. Am. Soc. C.E.
Dean Emeritus, Colleges of Engineering and Architecture, University of Michigan

Ann Arbor, Mich.
September 13, 1931

Sliding and Uplift Conditions Elucidated

EDITOR: In the article on "Safety Limitations of Hoover Dam," Mr. Gerry's comparisons with the St. Francis Dam are entirely illogical. This is apparent to anyone even roughly familiar with conditions at the two sites. There was nothing wrong with the design of the St. Francis Dam. The trouble there was entirely with the foundation, and there is no possibility of a similar foundation condition at the Hoover Dam. There are hundreds of dams of no more conservative design than that of the St. Francis, but on good foundations, which have given satisfactory service for years, and there is no record of failure of a dam of similar design on a good foundation. It is manifestly unfair to make an attempt, as Mr. Gerry has done, to use the troubles at the St. Francis Dam as examples of what may happen at the Hoover Dam.

Mr. Gerry claims that the Hoover Dam is not safe against sliding. He attempts to prove this by incomplete analysis, and arrives at the sliding factor of 0.94. If he had figured this correctly, and had taken all the forces into consideration—as should be done—his figure would be reduced by more than 20 per cent. But why all this worry about sliding? Even a casual knowledge of the methods used in the pouring of concrete on a rock foundation reminds one that the contact is so rough and irregular that a dam on a rock foundation could not possibly slide without first shearing the concrete, or the rock, or both.

The same condition exists in the "day's-work" joints within the body of the concrete itself. A dam built on a clay foundation could slide, and there are instances on record where a horizontal clay seam below the zone of contact has permitted the foundation to slide on itself, but such conditions do not exist at the Hoover Dam site. In considering the possibility of the Hoover Dam moving downstream, therefore, shearing stresses are controlling factors.

5-IN. CORE-DRILL SAMPLE FROM CONTACT PLANE
Showing Perfect Adhesion Between a Concrete Dam and Its Rock Foundation

The question of uplift forces is one that probably will be discussed as long as dams are being built. It is impossible for anyone to say just what such forces will be in any given case. However, it is not at all impossible to assume conditions which will be conservative and definitely on the safe side for any well explored dam site. I am unable to see how the upward pressure of water on a concrete dam, carefully tied into a good rock foundation, could possible act on anything like 100 per cent of the area of contact. Such dams do not float on their foundations. The only area on which uplift can act is where there is no actual contact. My opinion is that to consider the full pressure as acting on 50 per cent or less of the area of contact at the heel, diminishing to zero at the toe, is amply conservative. The same reasoning, of course, applies to possible uplift at horizontal joints in the dam itself.

The acompanying illustration is representative of the appearance of a number of 5-in. diameter cores cut out of the contact zone between the concrete and the rock of a dam I had under investigation a few years ago. In every case, in spite of the tendency of a core to become broken during the process of drilling and recovering, it was found that there was a close contact and definite adhesion between the concrete of the dam and its foundation. It is clear from this illustration that the contact was perfect. Under conditions like this it is hard to see how any uplift forces could exert themselves. This illustration does not show an exceptionally favorable case, but in my opinion is fairly representative of most of the contacts obtained under present-day methods, where ordinary precautions are observed.

CHARLES H. PAUL, M. Am. Soc. C.E.
Consulting Engineer

Dayton, Ohio
September 10, 1931

Full Arch for Hoover Dam

DEAR SIR: I was much interested in the article by Mr. Gerry in the July issue of CIVIL ENGINEERING. An inspection of the proposed Hoover Dam design gives the impression that it is intended to be a gravity dam and that the arching is added for whatever additional stability it may give. The cross section is a typical standard gravity section, and not an arch section. I was somewhat surprised, therefore, to learn that the dam was regarded as an arch dam carrying two thirds of the load on the arch, and leaving one third for the gravity action, especially since in previous reports on the subject it was stated that the arch dam idea had been discarded.

Tests showed quite conclusively that the Stevenson Creek arch dam was a very poor arch design. It began to show distress with a maximum compression of only around 1,200 lb. per sq. in. and a tendency to shear off at the top. The arch was too flat, especially toward the lower elevations. The proposed Hoover Dam, considered as an arch dam, has the material as inefficiently placed as has the Stevenson Creek Dam. It is too flat toward the bottom, where the upstream radius is approximately 1,200 ft. long (scaled), and yet the arch is to carry two thirds of the load.

A patent was issued to me in 1914, which has since expired, for a design in which the splitting of the load between arch, cantilever, and other actions was taken into consideration, and the result was an arch having its axis not of true circular shape at all elevations. It soon became apparent to me that too many assumptions must be made or overlooked (such as 100 per cent grouting, especially when this had to be done on a body never loaded) in making such a design reliable—the modulus of elasticity, E, is so sensitive and changeable; the sustained value of E is so different from its instantaneous value, and so different when the concrete is wet from when it is dry. The sustained value of E to be used for figuring cantilever deformation is approximately half the value which should be used for arch deformation, since for the cantilever the loaded side is dry.

The effect of water-soaking and its distribution, which may have still greater influence on the results than the

variable E, has not been dealt with by anyone in a rational manner as yet. Tests on a dam model, where the water is kept in a rubber bag and is not directly on the concrete, cannot be expected to give results comparable to those which may be expected from the prototype. The model is a three dimensional structure, whereas the real dam, after it has been in use for some time, can be regarded figuratively as four dimensional, the variable E and the water-soaking effect constituting the fourth dimension.

In a gravity dam there is some justification for limiting the stress to 30 tons per sq. ft. in compression, but it would not be good engineering to use such a low compressive stress in an arch design for a structure of the size of the Hoover Dam. If the Hoover Dam is to be designed to carry all the load as an arch, and the rock on which it is built has a compressive strength of 8,000 lb. per sq. in., as stated, it should be perfectly sound engineering to use a maximum arch compression of approximately 1,000 lb. per sq. in., in spots, for such a heavy section as the Hoover Dam will demand. With concrete having an ultimate compressive strength of around 5,000 lb. per sq. in., such an arch dam would have an ample factor of safety without assistance from any other member.

The gravity dams built in recent years, having base widths $66^2/_3$ per cent of their heights, would probably fail if subjected to full hydrostatic pressure under the base. However, full uplift under the base of arch dams worthy of the name would harm none of them.

It has been unanimously agreed that the Hoover Dam site is fine for an arch dam. Why an efficient arch dam should not be built there is difficult to see. Sometimes the inertia of the civil engineer is enormous. It is a well known fact that the highest dams built have been arch dams. Therefore, an arch dam should logically be built.

LARS JORGENSEN, M. Am. Soc. C.E.
Consulting Hydro-Electric Engineer

San Francisco, Calif.
August 31, 1931

Analogy Between Hoover Dam Site and Deep Granite Quarries

DEAR SIR: The criticisms of the design of the Hoover Dam by Mr. Gerry seem to be wrong. That a dam whose section is similar has failed is no argument. One might as well claim that a beam which is similar to one that has failed under entirely different conditions of support and loading, is not safe.

In connection with the doubts expressed by Mr. Gerry in regard to the stability of the canyon walls, a useful analogy might be drawn between the rock in the canyon and that in deep quarries. Deep granite quarries (over 150 ft.) are not commercially economical because the stone in the lower sheets or layers is weakened by the crushing weight of the high side walls. A unit volume of stone inside a large mass is compressed in all directions. Failure can only occur because of pure compression, unless the material is plastic in any direction and non-uniform in nature. However, exposure on one side eliminates the compression on that face. Due to the Poisson ratio effect, tension stresses are caused by the compression above and below. On the exposed faces there is no compressive resistance to neutralize this tension. Failure of the rock then occurs, in the form of diagonal shear cracks. The rock which forms the sides of Boulder Canyon is not as strong as it was before the cutting of the river channel. However, the addition of weight in the form of a concrete dam will replace the lost resistance and reduce the tension (and resulting shear stresses). The evidence shows that the rock was strong and durable and can be made strong and durable by the application of an arched dam.

The question of upward pressure on the base of dams founded on rock comes up again. The nature of rock in deep cuts as discussed above adds to the possibility of full upward pressure. The tendency of rock sheets to free themselves under pressure when a face is exposed opens fine but continuous water channels. The result in quarries left unworked for a number of years is a discoloration of the sheet faces. Such discoloration can only come from disintegration in the presence of water. If there are any possibilities of measuring the presence and amount of upward pressure under the Hoover Dam, tests will certainly be performed and conclusive data will then become available.

JACOB FELD, Assoc. M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.
October 10, 1931

Bonding Companies Do Not Qualify Contractors

DEAR SIR: I have followed with considerable interest the discussion regarding prequalification of contractors. The problem is, of course, how to prevent contractors not fully qualified both as to financial assets and experience from obtaining bond. One suggestion made in these pages was that the bonding companies should qualify contractors.

The difficulty in this proposition is well stated in a report by the Philadelphia Bureau of Municipal Research: "The surety bond does not guarantee responsibility against many of the indirect losses which grow out of defaulted or unsatisfactorily performed contracts. . . . It provides no protection against the numerous indirect losses which may result from unsatisfactory performance . . . . Millions of public money have been wasted through repairs, replacements, and delays due to poor workmanship, because of irresponsibility on the part of the constructor. Belief that price alone is to be considered because the city has its inspection and engineering forces to assure good workmanship, and a surety bond to assure the contractor's responsibility and reimburse the city for all losses, is erroneous. Neither fully protects."

In case of default on the part of the contractor, the bond simply protects the insured from loss in connection with the completion of the work under the specific terms of the contract.

On the other hand, it is doubtless true that bonding companies may be expected to be more familiar with the qualifications of different contractors than public officials can possibly be. In fact, the surety companies have provided for a certain degree of unified action in regard to contractors, a fact not generally known. Such cooperation is secured through what is known as the Bureau of Contract Information, Munsey Building, Washington, D.C., which is supported by the outstanding surety companies, who have banded together for this purpose. It will supply to any public official, engineer, or architect, free of charge, a very complete report on contractors' records. Unfortunately, there are a number of surety companies who, for reasons best known to themselves,

have not seen fit to cooperate with other companies in support of this bureau. Furthermore, what is more unfortunate still, is that these companies have not seen fit to join in other ways in eliminating the irresponsible contractor, so that what the Joint Conference on Construction Practices stated in 1924 is still true today, that: "Practically any contractor, whatever his financial standing; whatever his experience or lack of experience; whatever his equipment, sufficient or insufficient; whatever the relations of his liquid assets to the amount of work he has on hand; whatever the extent to which he has become over extended; can obtain a bond. Some surety company will execute bond for him and he goes from one company to another until he gets what he wants. The irresponsible contractor can usually find some company to go surety for him. This is the result of competition."

It will be seen that theoretically it should be possible for bonding companies to qualify contractors, but that practically, they do not. Those public officials who award contracts by the policy that the low bidder gets the job if he can get a bond, are merely passing along what is properly their own responsibility to the bonding companies.

Prequalification will not be a cure-all for these conditions but it at least should be a great help, and experience where it is now in vogue verifies this conclusion. Those who have tried it are universal in their opinion that public officials are much better able to rightly judge the contractor's responsibility separate and apart from the contingencies which arise after he is the low bidder.

HARRY J. KIRK
Assistant Manager, Engineering Construction Divisions
The Associated General Contractors of America, Inc.

Washington, D.C.
September 30, 1931

A Comparison of Wind Pressure Formulas

DEAR SIR: I should like to bring up a few points suggested by the articles and discussions on wind bracing in recent issues of CIVIL ENGINEERING. With reference to the formulas for transforming P, the horizontal wind pressure upon vertical plane surfaces into normal pressure, Pn, upon surfaces which are not vertical, the variation in pressure with respect to the slope angle, α, is given by a number of empirical formulas.

$$Pn = P\,\frac{2\sin\alpha}{1+\sin^2\alpha} \quad \text{..... (Duchemin) [1]}$$

$$Pn = P\,\frac{\alpha}{45} \quad \text{..... (Straight Line) [2]}$$

$$Pn = P\ \sin\alpha\ 1.84\ \cos\alpha - 1 \quad \text{..... (Hutton) [3]}$$

$$Pn = P\ \sin\ \alpha \quad \text{..... (Danish) [4]}$$

$$Pn = P\ \sin^2\ (\alpha + 20\ \text{deg.}) \quad \text{..... (French) [5]}$$

$$Pn = P\ \sin^2\alpha \quad \text{..... (German) [6]}$$

Formula 1 is considered to be the most reliable and is much used by American and British authorities. It is quoted by the Carnegie Steel Company, Redpath Brown, and Dorman Long in their handbooks, and is also recommended in well known American and English textbooks and manuals on engineering subjects.

Formula 4 is generally used in Denmark, while Formula 5 is usually used in France and has been adopted by French steel firms. Formula 6 appears to be much used in Germany. Of all these formulas, the Duchemin gives the most conservative values, and the German the least values. A comparison of these six formulas is shown in Fig. 1.

The Royal State Railways of Siam are planning to adopt one of them as the standard to be used in all specifications, since it has been found that the use of these different formulas depends upon the country from which the materials are ordered. This usually results in widely different results in designs and consequently in costs.

Rationally speaking, there should be one formula that is nearer the truth than the others. As there is a lack of good technical libraries and experimental research in

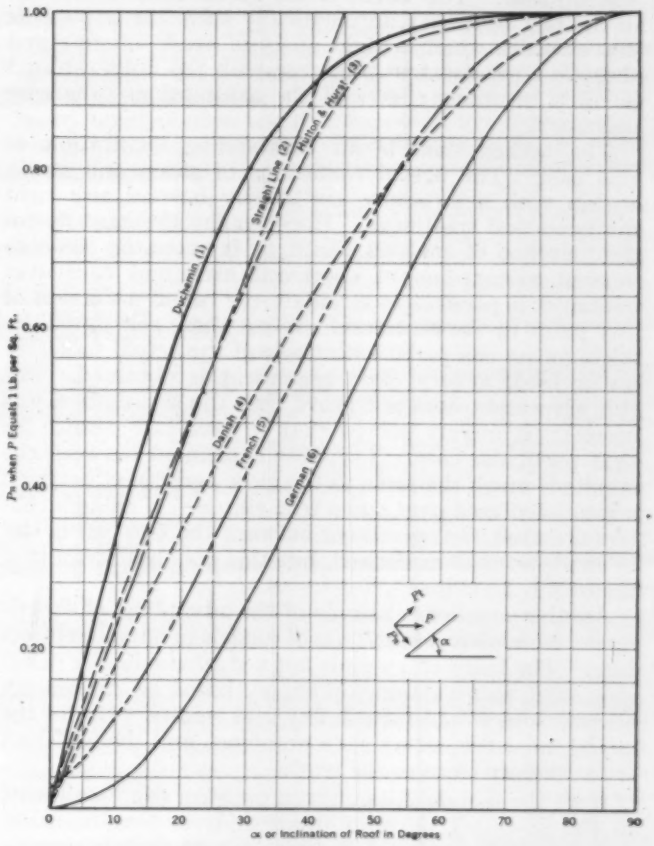


FIG. 1. WIND PRESSURES BY VARIOUS FORMULAS

Siam, I shall be very much obliged if any members of the Society will please cite their experiences with these formulas or give their opinions as to the one that is best for use in Siam.

SOONCHONG B. PUNYAGUPTA, Jun. Am. Soc. C.E.
Assistant Engineer, Technical Services

Bangkok, Siam
August 30, 1931

Value of Experimental Models

TO THE EDITOR: In view of the increasing employment of experiments with models in the design of works of all kinds and classes, the article by Mr. Stevens in the September issue of CIVIL ENGINEERING is very timely. He has briefly and concisely summarized the conditions required to attain similitude between model and prototype and has pointed out that intelligent interpretation of the observations is quite as important as extreme care in carrying out the experiments. The use of models

for this purpose is not by any means new. It is on record that the famous old Britannia Bridge, built about 70 years ago, was designed very largely by such methods.

Experiments with models are of greatest value for those problems which involve a highly complicated theoretical treatment of the data and for those in which the available theory is little more than a convenient makeshift for the unknown truth. No matter how simple any phenomenon of nature may seem, it is in reality so complex that a rigid mathematical analysis is impossible. If any analysis at all is to be attempted some simplifying assumptions must be made. Even then the results of the analysis will be no better than the assumptions. The virtue of the model experiments lies in the fact that they automatically solve the impossible mathematics which a rigid analysis would involve and thus, to a great extent, dispense with the unknown and possibly injurious effects of the assumptions otherwise necessary.

The arched dam is an outstanding illustration of this case. The actual conditions of stress and strain within such a structure are utterly beyond any rigid mathematical treatment. However, by the most up-to-date method of analysis, based, be it noted, on the convenient assumption of combined arch and cantilever action, it is possible to calculate the radial deflection of any point in the structure. When those calculated deflections are compared with those of the actual structure under load, a very close agreement is obtained. But this agreement does not prove that the assumption was correct; it merely proves that it gave safe results for that particular case. The close agreement between the results is much the same as the close agreement between a multi-centered oval and a true ellipse. If enough centers are used, the agreement between the two curves can be made as close as desired, but this does not mean that the oval is an ellipse.

Another excellent example of the advantage of experiments on models is in the use of models in naval architecture. The body of a ship is not a mathematically definable solid, so no amount of theory based on convenient assumptions would furnish any real results. Use of the model, however, solves such problems, and the solutions are strikingly close to the truth.

If all the factors in any given problem can be reduced to the so-called physical dimensions of length, mass, and time, the results of observations on models may be reduced to a formula which can be applied with a reasonable degree of confidence to the full-sized prototype. The departures of prediction from performance will arise mainly from two unavoidable causes. One of these is the difficulty of making measurements on the model with the same relative degree of accuracy that can be secured on the prototype. The other is the inevitable departure in homogeneity, isotropy, and exactness of construction which are sure to be found in the prototype as compared with the model.

When models are used for the design of hydraulic structures, the proviso in the foregoing paragraph will almost certainly apply. There are factors in practically all hydraulic problems which cannot be expressed in the three physical dimensions and, in consequence, cannot be measured, described, or duplicated. For example, roughness of wet surfaces is one factor for which we have no physical unit of measurement, so it cannot be introduced into a formula except by a numerical coefficient. Other such factors are shape of cross section and alignment, shape and location of obstructing piers and other obstructions, and shape of weir-crests and the like.

As a result of these limitations, experiments on models of hydraulic structures will probably require greater care and more intelligent handling than would otherwise be necessary. I have emphasized the precautions which are required if worthwhile results are to be obtained. While all these precautions should be observed when possible, it still remains true that even crude experimentation in careful and intelligent hands will give fair, if not good, results and the best of apparatus improperly handled may be worse than useless.

H.B. MUCKLESTON, M. Am. Soc. C.E.
Consulting Engineer

Vancouver, B.C.
September 28, 1931

Requisites for a New Formula for Reinforced Concrete Columns

DEAR SIR: I have been greatly interested in the articles and discussions on reinforced concrete, as prompted by the paper by Messrs. Gilkey and Raeder in the July number of CIVIL ENGINEERING, and particularly with regard to the stresses in the steel reinforcement.

According to the information in *Bulletin 190*, of the University of Illinois, dealing with spirally reinforced columns, the lateral compression resisted by the spiral hooping is so small that it may be neglected until the unit load is equal to from 70 to 85 per cent of the strength of the plain concrete. Beyond this point the loading is in what may be called the "spiral stage." The conditions of the experiments were ideal for the testing of the spiral reinforcement, as the longitudinal reinforcement, which spaces the spiral steel, amounted to only 0.3 per cent.

Plain concrete in compression fails progressively through the stages of elastic stability, plastic deformation, and the breaking up of the internal structure due to splitting action. During the stage of plastic deformation the lateral deformation of the concrete produces small stresses in the spiral reinforcement, and the disorganization of the internal structure of the concrete requires the lateral support of this reinforcement. The concrete will then carry additional load only as fast as the spiral reinforcement will develop the necessary lateral support.

An indication of the lateral support provided by the spiral reinforcement (*Bulletin 190*) was shown by the ability of the concrete core, originally tested to failure as a spirally reinforced column and then having the spiral hooping removed, to carry a load which was 49 per cent of that taken by a plain column.

The development of a formula would have to consider the stress and strain relationships during the "spiral stage," lateral restraint by the spiral reinforcement to prevent buckling in the practical column, and plastic flow. Plastic flow, which has shown our vertically reinforced tied columns to be theoretical failures, in the spirally reinforced column would be reduced to a minimum. The lateral flow of the concrete between the openings of the spiral column could be remedied by the substitution of thin steel cylinders for the spiral hooping, as suggested by Mr. Molitor.

SAMUEL T. CARPENTER, Jun. Am. Soc. C.E.
Engineer Apprentice, McClintic-Marshall Corporation

Leetsdale, Pa.
September 30, 1931

SOCIETY AFFAIRS

Official and Semi-Official

Fall Meeting in St. Paul

St. Paul did itself proud in entertaining the members of the Society and their guests, to the number of four hundred, gathered for the Fall Meeting in the "Northern Region." This attendance was excellent, and the interest shown in the various gatherings left little to be desired.

On Wednesday morning, the general session was called to order by William N. Carey, President of the Northwestern Section. His Excellency, Governor Olson, and His Honor, Mayor Bundlie, in their addresses set splendid examples of simple and genuine welcome that instantly won their hearers. President Stuart responded to the welcomes, and then delivered an address on the engineers' place in the solution of the problems which lie at the root of our economic ills.

It is gratifying to note that during the Wednesday morning session the President of the Engineering Institute of Canada, S. G. Porter, M. Am. Soc. C.E., of Calgary, Alberta, sat on the platform. His presence and the attention paid to it was a mark of courtesy to a sister society.

The rest of Wednesday morning was devoted to the presentation of two technical papers dealing with the iron mining industry, and one on general unemployment and industrial conditions. Needless to say, close attention was paid to these vigorous presentations of timely subjects, all three of which were given by men not members of the Society. There was an even larger attendance at the afternoon meeting devoted to the St. Paul development program, to economic phases of railroading, and to the upper Mississippi waterways.

Herbert S. Crocker Nominated for President

The Nominating Committee, meeting in St. Paul on October 5, as required by the provisions of the Constitution, chose as its nominee for President for 1932, Herbert S. Crocker, M.Am.Soc.C.E., of Denver. Colonel Crocker has been a Member of the Society for thirty years and has served both as Director and as Vice-President. He also holds the unique distinction of having been Acting Secretary for one year, during 1920. A more extended account of the official nominee for President will appear in a later issue.

Student Conference a Success

The Student Chapter Conference, called to order at 4 p.m., exceeded all expectations by overflowing the available meeting room by perhaps 50 per cent. Representatives and members from about a dozen Chapters were on hand, to the number of 90 men, while about 20 members of the Board, Faculty Sponsors, Contact Members, and interested members of the Society gave close attention to the proceedings. Adjournment at 6 p.m. was necessary, but unfinished business was continued the next morning at an extra session of the delegates from the Chapters. Seldom has interest been keener in this phase of Society activity.

On Wednesday evening, 150 persons sat down to a splendidly prepared dinner in the ballroom of the Hotel Lowry. It was no occasion for dieting, and none was observed. The address of the evening was by Dean Ford of the Graduate School at the University of Minnesota, whose audience was attentive and appreciative. Dancing followed. It is always a pleasure to record that the enjoyment of this feature is not by any means confined to the younger folk.

Sessions of Divisions Are Impressive

Thursday morning saw three Technical Divisions under way—Highway, Surveying and Mapping, and Sanitary Engineering. Enthusiasm marked them all, and unusually good discussion took place. In the afternoon a bus trip around the Twin Cities included numerous points of interest, while many smaller groups made trips to special works. That evening was devoted to an informal dinner entertainment and dance at the St. Paul Athletic Club, where good fellowship continued until a later hour.

On Friday morning the City Planning Division held a small but intensive session, while the newly formed Engineering-Economics and Finance Division conducted the first technical session in its existence. More than 100 members gave close attention to the initial program. This was followed by a meeting of the Division's Executive Committee to formulate the objectives of the group as well as to complete plans for the session at the time of the Annual Meeting.

Following the final technical session, a party of about 25 left by rail for Duluth, others going by automobile. Upon arrival, the Duluth Local Section entertained the visitors at dinner in the charming Kitchi Gammi Club, followed by a talk, illustrated with motion pictures, on the Mesabi Iron Range, to be visited the next day.

Thoughtful consideration governed the Duluth hosts in permitting their guests to retire early, since 5:30 a.m. is always a bit early to arise. No one missed breakfast, and at the appointed hour a bus load started for Hibbing. Four members of the Duluth Section acted as guides and mentors, adding tremendously to the visitors' understanding of the new scenes.

An observation car and locomotive were provided by the Oliver Mining Company, together with a sizable staff of officials to accompany the visitors. Here also the party was augmented by a number of members who had driven up by automobile. The train dropped down the long grade into the pit and ultimately traversed the greater part of the works, giving an intimate glimpse of the greatest open-pit iron mine in the world.

When the party returned to the surface luncheon was obtained, and then the return trip started, which was by way of several other famous mines and mining towns. The approach to Duluth was via the beautiful Run-Drive looking down on the city. Upon arrival the visitors boarded a train for St. Paul and the Meeting was over.

Ladies Entertained Royally

No account could be complete without a record of the special entertainment provided for the ladies. This included an automobile drive Wednesday morning, through the park and residence sections of St. Paul and Minneapolis, luncheon at the Lafayette Country Club, followed by bridge, golf, or a continuation of the drive. The ladies were guests of the Northwestern Section for this trip. On Thursday morning a bus and boat trip was much enjoyed by the ladies, including a two-hour steamer ride down the St. Croix River. Luncheon was served on board, so that no opportunity was lost to enjoy the autumn foliage along the river. Those ladies who were in St. Paul in advance of the meeting were entertained at tea by Mrs. Ralph Budd on Monday afternoon, and attended a theater party Monday night. There was also a luncheon for them on Tuesday, given by Mrs. Day Okes at the University Club.

Many details contributing to the success and efficiency of the Meeting were capably handled by members residing in the Twin Cities. The executive committee supervising the arrangements, to whom great credit is due, included in its personnel the following: Ralph Budd, Honorary Chairman; W. N. Carey, George E Loughland, M. W. Hewett, H. D. Lovering, J. A. Childs, Hibbert M. Hill, J. R. Johnston, Frederic Bass, George M. Garen, F. C. Shenehon, W. E. Smith, George H. Herrold, W. L. Darling, W. T. Walker, G. L. Wilson.

Secretary's Abstract of Minutes of Board of Direction Meeting

St. Paul, October 5, 6, 1931

The Board met in the Hotel Lowry at St. Paul, Minn., on October 5 and 6, 1931; with President Francis Lee Stuart in the chair; and present: George T. Seabury, Secretary; and Messrs.

Buck, Budd, Chester, Coleman, Dusenbury, Gowdy, Herrmann, Howe, Jacobs, Lupfer, MacCrea, Marston, Mead, Mendenhall, Morris, Morse, Nicholson, Reichmann, Singstad, Slattery, Stevens, Thomas, Waite, and Winsor—that is, there was only one absentee.

Approval of Minutes of Board

The minutes of the meeting of the Board held at Paradise Inn in the State of Washington on July 6 and 7, 1931, were approved.

Incoming Board Members to Attend January Meeting

In accordance with the practice of recent years, those who will become members of the Board in January next will be invited to attend, as observers, the sessions of the outgoing Board.

Appointments to Engineering Council

Representatives were appointed to the American Engineering Council for the two-year term ending January 1934, as follows: Baxter L. Brown, L. L. Calvert, J. F. Coleman, A. J. Dyer, Frank M. Gunby, Charles H. Paul, and George T. Seabury—all reappointments.

Society's Program for Relief of Unemployed Engineers

A program for the immediate relief of unemployed engineers, as suggested by E. P. Goodrich, Chairman of the Society's Committee on Salaries, was enthusiastically adopted. The plan proposes the grouping of the employed engineers in each Local Section to give financial support to such engineers in the community as may be in need and to organize a systematic survey by the unemployed engineers for discovery of suitable projects within the community which can be carried on under the auspices of the community's general unemployment relief organizations. [The elements of the plan and certain suggestions which accompanied its announcement to the Local Sections will be found elsewhere in this department.]

Unemployment and Industrial Stabilization

The Board approved in principle a program suggested by American Engineering Council, by which engineers in each community are urged, unitedly and in full cooperation with other agencies, to study the problem of unemployment and the stabilization of industry in each community.

Council's suggested program is based on the resolution adopted by its Administrative Board which reads as follows:

"That Council, through its Public Affairs Committee, take immediate steps to enlist our member organizations in a constructive program of study and action aiming to preserve the essential laws and principles under which our people in the past have achieved unparalleled prosperity and to counteract doctrines that might produce results adverse to the national well-being."

Pursuant to the above, the program suggested by Council's Public Affairs Committee is said to have two aspects, "the one to relieve unemployment during the present depression—the other to develop plans for the permanent stabilization of employment."

Temporary Expansion of Mapping and Stream Gaging

The Board adopted a vigorous resolution requesting the Congress of the United States to appropriate at the earliest possible moment the sum of $4,000,000 to be available immediately to proper departments of the Federal Government for the prosecution of topographical surveys, stream gagings, and studies of flood control and water resources at an increased rate of speed during the calendar year 1932.

The resolution further placed upon the members of the Society, individually and as organized in Local Sections, the obligation to urge upon their national representatives the introduction and support of such measures; and upon their state legislatures the taking of the necessary steps by means of suitable appropriations, in order that there may be full participation with the Federal agencies in such approved temporary expansion of the mapping and stream gaging programs as may be initiated. [The full text of the resolution appears on a following page.]

In Support of President Hoover

By resolution, too, the Board commended President Hoover for his efforts to relieve the distress caused by the present unemployment situation and pledged the support of the Board of Direction. [The resolution in full appears elsewhere in this department.]

Local Section Constitutions Approved

Approval was given to certain changes proposed in the constitution of the San Francisco Local Section.

Similarly, approval was given to changes proposed in the constitution of the Texas Local Section whereby, while remaining a state-wide section, provision is made for the formation within the Section of Local Branches in the large cities. The Board, recognizing in this a procedure which might become universal, had referred the question to the Society's Committee on Local Sections, and the Board's action was in endorsement of the recommendation of that committee.

Professional Conduct

The Board acted upon nine cases reported to it by the Committee on Professional Conduct. A hypothetical question which had been referred to that committee was answered.

Honorary Memberships

The following were elected to Honorary Membership: Daniel W. Mead, George W. Kittredge, George H. Pegram, and Palmer C. Ricketts.

Registration of Engineers

Accompanied by a report of the Committee on Registration of Engineers, the Uniform Registration Law—which was drafted by 19 representatives from 11 collaborating engineering groups brought together in Society Headquarters at the instance of the Society's committee, and which was submitted to the Board at the time of its meeting in July last—was approved with two reservations. The committee was charged with the duty of submitting both reservations to the cooperating groups or their representatives, with the intent that, if and as incorporated in the so-called Uniform Registration Law, it shall become a model law, indicating the features desirable in new or amendatory legislation.

Of the two features suggested for reconsideration, the more significant is the incorporation in the law of a provision that, after a period, registration shall be granted only to those who, having the necessary other requirements, have also an education provided in an approved technical institution, or to those proving by examination that they have acquired by other means the full equivalent of such technical education.

Executive Committee Report

The report of the Executive Committee was confined to financial matters and embraced several recommendations, which with slight modifications were adopted by the Board as instructions to the Executive Committee in its preparation of the 1932 budget.

Significant among these was the decision to omit the 1932 Spring Meeting proposed to be held at Miami, Fla., and to hold the Convention in July in Yellowstone National Park. Decision as to the holding of the usual quarterly meeting in the fall was deferred.

Resolution on Death of George Fillmore Swain

The Board, having previously expressed its deep regret at the death of George F. Swain, Past-President and Honorary Member of the Society, approved a resolution to be incorporated in the minutes of the Board.

Appreciation of Ambrose Swasey's Fourth Gift to Engineering Foundation

On behalf of the American Society of Civil Engineers, its Board of Direction, in regular meeting at St. Paul, expressed appreciation to Ambrose Swasey, Hon. M. Am. Soc. C.E., for his fourth generous gift to the Engineering Foundation, of which it had been informed by the United Engineering Trustees, Inc. The Board is impressed and inspired by Mr. Swasey's steadfast interest in the welfare of the Founder Societies, and the obligation put upon them by his series of gifts "for the furtherance of research in science and engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind."

Society Prizes Awarded

Confirming the report of the Society's Committee on Prizes, the following awards were made for 1931:

The Norman Medal, to Floyd A. Nagler and Albion Davis, Members Am. Soc. C.E., for their paper No. 1744 ("Experiments on Discharge Over Spillways and Models, Keokuk Dam").

The J. James R. Croes Medal to John R. Freeman, Hon. M. Am. Soc. C.E., for his paper No. 1726 ("Flood Control on the River Po in Italy").

The Thomas Fitch Rowland Prize to Samuel A. Greeley, M. Am. Soc. C.E., and William D. Hatfield, Assoc. M. Am. Soc. C.E., for their paper No. 1738 ("The Sewage Disposal Works of Decatur, Ill.").

The Arthur M. Wellington Prize to George F. Schlesinger, M. Am. Soc. C.E., for his paper No. 1736 ("The Practical Utility of Highway Transport Surveys").

Alfred Noble Prize

Confirming the report of the joint Committee on the Alfred Nobel Prize, the first of these awards was made to C. T. Eddy, Associate Member of the American Institute of Mining and Metallurgical Engineers, for his paper, "Arsenic Elimination in the Reverberatory Refining of Native Copper," presented at the February 1931 meeting of the American Institute of Mining and Metallurgical Engineers, and published in January 1931 as Technical Publication No. 403.

* * * *

The Committee on Districts and Zones recommended that there be no change in the boundaries of the Districts or Zones in the coming year.

* * * *

There was the usual consideration of administrative details, resignations, reinstatements, committee and other appointments, admissions, and transfers of members.

Adjournment

The Board adjourned to meet at 10 a.m., Monday, January 18, 1932, at Society Headquarters, at the time of the Annual Meeting.

October Society Meeting

As the Constitution requires that a business meeting of the Society be held during October, this meeting was held on October 21 in conjunction with and just preceding that of the Metropolitan Section, at 8:00 p.m., in the Engineering Societies Building. President Francis Lee Stuart, who presided, gave the opportunity for the presentation of Society business. There being none, he called upon the Secretary for announcements, after which the meeting was adjourned.

First Award of Alfred Noble Prize

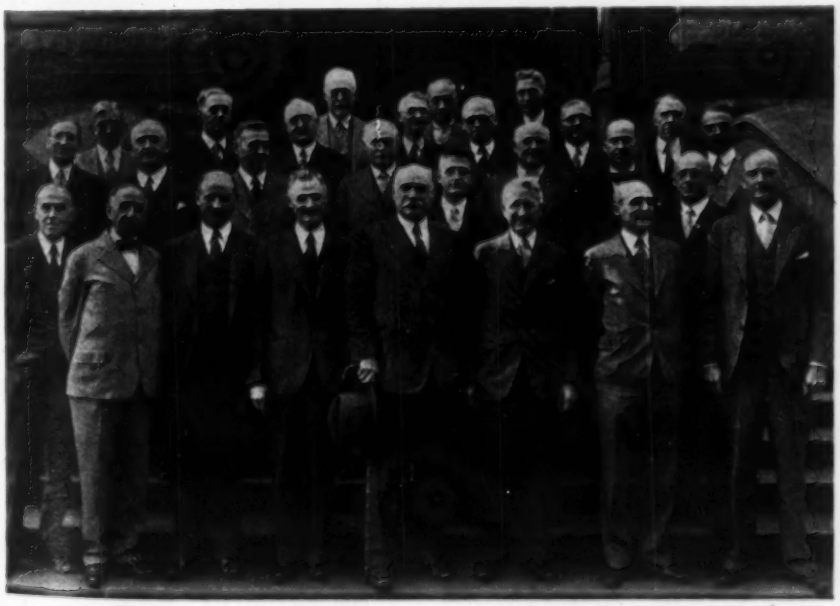
By concurrence of the Board of Direction in the recommendation of the Committee on the Alfred Noble Prize, this honor for the year 1931 has been awarded to Prof. C. T. Eddy, of Michigan College of Mining and Technology, at Houghton, Mich. This is the first award of this prize, which is accompanied by $500 in cash. It should be of interest to all the younger members of the engineering profession.

Older members of the Society well remember Alfred Noble. During a professional career of over 50 years, ending in 1914, he participated in a great number of public works, for which the citizens of this country still remain his debtors, although his characteristic modesty prevented his name being known in connection with them.

His experience was of value in connection with the location and construction of the Panama Canal. He was one of the engineers who built the Pennsylvania Terminal in New York City. The project of bringing water from the Catskill Mountains to the City of New York was guided in part by his knowledge and advice. In addition to his technical achievements, Mr. Noble took a great interest in the welfare of his colleagues, and especially in the younger men who were just starting out in the profession of engineering.

Very soon after his death, the Society appointed a committee to collect funds for a memorial to perpetuate the memory of this highly honored member and Past-President. This has finally taken shape in a fund, the income of which is to be used for an annual award of $500 to a younger engineer who might thereby be encouraged in his chosen work, and be led to emulate Alfred Noble, though he had never had the privilege of knowing him.

The prize is awarded upon the recommendation of a committee consisting of representatives from the four Founder Societies and the Western Society of Engineers. The award is made for a technical paper of particular merit written by a member of one of these societies, and accepted for publication before the author has reached the age of 30 years. The paper by Professor Eddy, on "Arsenic Elimination in the Reverberatory Refining of Native Copper," published as Technical Publication No. 403 of the American Institute of Mining and Metallurgical Engineers, of which he is a member, was adjudged worthy of the first award. The presentation will take place at a future meeting of the Institute, and the prize will be given to Professor Eddy by a representative of the American Society of Civil Engineers, the trustee of the fund.



THE BOARD OF DIRECTION AT THE FALL MEETING IN ST. PAUL, OCTOBER 7–10, 1931
Taken at the 4th Street Entrance of the City Hall and Court House

First row, left to right: George T. Seabury, Secretary, New York; Joseph Jacobs, Director, Seattle; Ole Singstad, Director, New York; Frank L. Nicholson, Director, Norfolk; Francis Lee Stuart, President, New York; E. K. Morse, Director, Pittsburgh; D. A. MacCrea, Director, Little Rock, Ark.; Franklin Thomas, Director, Pasadena. Second row; Ralph Budd, Director, St. Paul; Edward P. Lupfer, Director, Buffalo; J. F. Coleman, Past-President, New Orleans; Anson Marston, Past-President, Ames, Iowa; A. P. Richmond, Assistant to the Secretary, New York; J. N. Chester, Vice-President, Pittsburgh; John R. Slattery, Director, New York; Allan T. Dusenbury, Director, New Orleans; Henry R. Buck, Director, Hartford. Third row: Charles H. Stevens, Director, Philadelphia; A. F. Reichmann, Director, Chicago; Roy C. Gowdy, Director, Denver; F. C. Herrmann, Director, San Francisco; Frank E. Winsor, Vice-President, Boston; H. D. Mendenhall, Director, Lakeland, Fla.; J. M. Howe, Vice-President, Houston. Fourth row: Charles A. Mead, Director, Newark; H. M. Waite, Vice-President, Cincinnati; Clyde T. Morris, Director, Columbus.

Board of Direction Resolution Urges Accelerated Mapping and Stream Flow Program

The full text of the resolution adopted by the Board of Direction at St. Paul requesting a Government appropriation for an accelerated program of topographic mapping, stream gaging, flood control, and studies of water resources follows:

WHEREAS thousands of civil engineers are unemployed and many are in actual need; and

WHEREAS authorization under the so-called "Temple Act," has already been provided by the Congress of the United States for the mapping of the country in a period not to exceed 20 years; and

WHEREAS this work has not received appropriations which would permit the work to go forward as planned; and

WHEREAS it would be of great benefit to the nation, if work on topographical surveys, stream gaging, and studies of flood control and water resources, in certain parts of the United States, could be expedited:

Now, therefore, be it resolved by the Board of Direction of the American Society of Civil Engineers that the Congress of the United States be requested—

First: To appropriate at the earliest possible date the sum of four million dollars ($4,000,000) to be made available immediately to proper departments of the Federal Government for the prosecution of said surveys, stream gagings, and studies, at an increased rate of speed during the calendar year 1932; and

Second: To authorize and direct the heads of the various departments to temporarily expand their departments, and to waive such civil service rules as may be necessary to give preference to competent unemployed and needy engineers and surveyors, in building up the forces necessary for said work; and

Be it further resolved: That members of the American Society of Civil Engineers, individually, and as organized in Local Sections of the American Society of Civil Engineers, urge upon their representatives in Congress the introduction and support of such measures.

And further: That they urge upon their respective state officials that the several states take the necessary steps by means of suitable appropriations to participate fully with the Federal Government agencies in such approved temporary expansion of the mapping program as may be initiated.

And further: That copies of this Resolution be sent to the President of the United States, members of Congress, and state governors.

New Honorary Members Selected

Notable additions to the list of Society Honorary Members were effected by the election, at the St. Paul Meeting, of four men by the Board of Direction. These new Honorary Members, who have now formally accepted this designation, are as follows: George W. Kittredge, Daniel W. Mead, George H. Pegram, and Palmer C. Ricketts.

It is expected that these distinctions will be officially awarded at the time of the 1932 Annual Meeting. A brief historical sketch of these four men will appear in a later issue.

Society Badges as Christmas Gifts

A certain sentiment seems to be associated with the owning and wearing of a Society badge. Perhaps this fact, or the meaning attached to the emblem itself, accounts for its popularity as a Christmas gift. Each year at about this time an increase in the number of orders for pins is noted. On the assumption that this is because of the holiday season, it seems undeniable that they are destined as gifts for members. Certainly a Society badge lacks nothing of being a perfect gift, where it is otherwise appropriate.

Those that have had this matter in mind for some time will need no further reminder. To others, however, the suggestion may come at an opportune time. It is mentioned thus early so that orders may be received in ample time to have the necessary engraving and other details attended to.

New orders are placed immediately when received. For the replacement of lost pins, however, a statement that the pin has been lost is required, inasmuch as Society regulations prohibit the sale of a second badge to any member while the first is in his possession. Badges of corporate members, if turned in for replacement, are credited with an allowance of $1.25. Further conditions regulating the use of Society badges are noted on page 49 of the 1931 Year Book.

Dr. Pupin Awarded John Fritz Medal for 1932

To Dr. Michael I. Pupin, of Columbia University, the John Fritz Medal Board of Award, at its regular annual meeting on October 16, 1931, awarded its gold medal. The award was made to him as scientist, engineer, author, and inventor of the tuning of oscillating circuits and the loading of telephone circuits by inductance coils. This award, the highest honor given by engineers of the United States, was made by unanimous action of a board representing the four Founder Societies.

Dr. Pupin is Professor of Electro-Mechanics and Director of the Phoenix Research Laboratory at Columbia University. Among engineers and scientists he is widely known for his researches and inventions in connection with long-distance telephone lines, and for his advanced work in the passage of electricity through gases, electrical resonance, electrical wave transmission over long conductors, and many other scientific subjects. To many thousands of persons, the fascinating story of his life has been made known through his inimitable autobiography, "From Immigrant to Inventor," and his other writings.

He was born a Serb, in a province of Hungary, on October 4, 1858. He came to America as a young boy and after many courageous struggles won an opportunity for an education. He was graduated from Columbia University in 1883, studied at the University of Berlin, attained the degree of Doctor of Philosophy in 1889, and subsequently was granted the degree of Doctor of Science by Columbia and Princeton universities, and Doctor of Laws by Johns Hopkins University, New York University, Muhlenberg College, and other educational institutions.

He is a former president of both the American Institute of Electrical Engineers and the American Association for the Advancement of Science. He is also a member of the National Academy of Sciences, the New York Academy of Sciences, the American Philosophical Society, the American Physical Society, and other learned bodies, and a past chairman of the Engineering Foundation.

Dr. Pupin has received numerous other honors, including the Edison Medal of the American Institute of Electrical Engineers, and the Carson Gold Medal of the Franklin Institute. During the War, 1917–1918, he served on the National Advisory Committee for Aeronautics and other bodies doing scientific research work to aid our government.

Prize Winners Named

Prizes for the current year were approved by the Board of Direction at the St. Paul Meeting, as noted in detail in the abstract of the minutes of the Board on a previous page. Papers appearing in Vol. 94 of TRANSACTIONS 1930, were made the basis of choice. It is customary to bestow these distinguished prizes officially at the time of the Annual Meeting. This ceremony is therefore expected to form one of the interesting features of the session on Wednesday, January 20, 1932. Further statements concerning the prizes and their recipients will appear in a coming issue.

Appointments of Society Representatives

BAXTER L. BROWN, M. Am. Soc. C.E.; L. L. CALVERT, M. Am. Soc. C.E.; J. F. COLEMAN, Past-President Am. Soc. C.E.; A. J. DYER, M. Am. Soc. C.E.; FRANK M. GUNBY, M. Am. Soc. C.E.; CHARLES H. PAUL, M. Am. Soc. C.E.; and GEORGE T. SEABURY, Secretary, Am. Soc. C.E., have been reappointed to represent the Society on the American Engineering Council.

HERBERT D. MENDENHALL, Director Am. Soc. C.E., was the official representative of the Society at the Annual Meeting of the National Council of State Boards of Engineering Examiners held in Detroit.

Resolution on the Death of George F. Swain Adopted by the Board of Direction

"In the death of George Fillmore Swain on July 1, 1931, the Society lost one of its oldest and most distinguished members.

"Professor Swain's membership in the Society, extending over a period of 48 years, was one of continued interest in its affairs. His devotion to the Society is evidenced by the many eminent offices that he held, serving successively as Director, Vice-President, and as President. In recognition of his many and outstanding contributions to the profession, he was awarded the highest distinction within the gift of the Society, by being elected to Honorary Membership in 1929.

"Professor Swain gave without stint to his profession. He was a contributor to the Society's publications, and his writings on technical matters comprise a valued chapter in engineering literature. In the field of engineering education, Professor Swain was one of the recognized leaders. The affection of his former students for him is evidence of their esteem of his character and their appreciation of the value of his counsel and continuous interest in their success.

"Professor Swain was known for his unswerving adherence to strictest ethical principles. His was not the nature to compromise with anything short of his own ideal of perfection. He was a staunch friend, willing to prove it by deeds as well as words on any occasion. He therefore left a lasting and vivid impression on his wide circle of students and colleagues. His presence and valued opinions will be sadly missed in all Society and educational circles.

"The Board of Direction hereby expresses its deep regret in the loss of Professor Swain, and extends its sympathy to the members of his family."

Supporting President Hoover

Among the actions taken by the Board of Direction at the recent Fall Meeting was one dealing with the present economic situation. The action of the Board, which deserves notice in full, is indicated by the following resolution, dated October 6:

"The Board of Direction of the American Society of Civil Engineers, in regular session, held this day at St. Paul, Minn., recognizes the serious depression which prevails throughout the civilized world, involving dislocation of industry and widespread unemployment.

"The Board commends the President of the United States for his organization of national and local committees along non-partisan lines and of outstanding personnel for the handling of the unemployment problems which have arisen, and which will arise during the coming winter, and also for the consideration of various ways and means of avoiding such crises in the future.

"The Board pledges its support of, and cooperation with, such measures and will use its best efforts to encourage the 15,000 members of the Society individually to assist in promoting, in every way possible, the work of the regularly constituted relief organization."

Following the action of the Board, the wording of its resolution was immediately telegraphed to Mr. Hoover. In reply, the President wrote a letter of appreciation, the text of which is reproduced herewith.

Every member of the Society, sympathizing with the motives prompting this action and with the ends in view, may well note the ideals expressed by the Board. Combined action on this worthy project should make a valuable contribution to the alleviation of present conditions.

THE WHITE HOUSE
WASHINGTON

October 7, 1931.

My dear Mr. Seabury:

The action of the Board of Direction of the American Society of Civil Engineers is very gratifying and the pledge of support and cooperation conveyed by your telegram of October 6th are very much appreciated.

Thank you for wiring.

Yours faithfully,

Herbert Hoover

Mr. George T. Seabury
33 West 39th Street
New York, New York

Transactions, Vol. 95, Now in Print

A worthy addition to a long and notable series has made its appearance in Vol. 95 of TRANSACTIONS. This 1931 volume, the most recent of a sequence dating back to separate papers written in 1867, will soon be, if it is not already, in the hands of members. The scope of its authority in the field of civil engineering is attested in numerous ways. A simple statement of a few statistics will serve to indicate this in a general manner.

It contains 22 papers, 6 reports, and 2 symposiums. The subject index includes 110 headings, pointing the way to the 161 items into which the 30 papers are indexed and cross-indexed. In the author index are listed the names of 219 contributors and of 245 papers to which they contributed.

It is noteworthy that 4 of these contributors also appear in the list of memoirs published in the same volume, thus bearing eloquent witness to their sense of responsibility as members of the Society right up to the end of their days. The names of these members are William Cain, Allen Hazen, Robert Grier Hemphill, and Frank Martin Williams.

The section dedicated to the publication of memoirs of deceased members has an especial interest in this volume, inasmuch as this is the first time that memoirs for a given year have appeared once only together in a single volume. Previous to this time, memoirs were published in PROCEEDINGS month by month in the order submitted; but recently that practice was discontinued and certain memoirs have been prepared in advance month

by month and made available to members for distribution in the form of preprints from TRANSACTIONS. Hence, the memoirs division of Vol. 95 has unusual value, as members who find themselves particularly interested in any one memoir may receive a copy by applying directly to Headquarters. The list includes the professional records of 4 men in the category of Honorary Member or Past-President, 102 Members, 19 Associate Members, 1 Junior, and 2 Affiliates.

Classifying the subject broadly, this volume of TRANSACTIONS contains papers on power transmission, waterways, materials of engineering, dams, surveying and mapping, structural engineering, city planning, tunnels, rainfall, water works, water power, hydrology, transportation, drainage, irrigation, highway engineering, power plants, and sanitary engineering. These are well divided in scope among the various Divisions of the Society and therefore should promise much of especial interest to every member.

Fitting Souvenir of St. Paul Meeting

Members attending the Fall Meeting of the Society at St. Paul, held October 7–10, were agreeably surprised to discover the extent of the preparations which had been made for their enjoyment and convenience. One of the items in this program was a souvenir edition of *The Bulletin* of the Minnesota Federation of Architectural and Engineering Societies.

This, the October number, was an attractive book of 60 pages devoted almost exclusively to matters of interest to those attending the meeting. Articles on the Society, its officers, and details of the ensuing program, opened *The Bulletin*. There succeeded interesting stories of St. Paul, Minneapolis, Duluth, and the surrounding country, delightfully illustrated with a generous supply of photographs, drawings, and maps.

Little was left for a complete understanding of the Twin City District, its engineering and civic features. Aside from the inherent interest in the information contained and its attractive set-up, *The Bulletin* provided a most suitable souvenir and reminder of the Meeting itself. George H. Herrold, M. Am. Soc. C.E., as editor of *The Bulletin* and Chairman of the Publicity Committee for the Meeting, deserves great credit for his successful efforts.

Further Memoirs Available

Since the publication of the long list of memoirs prepared by the Society, as given in the August issue of CIVIL ENGINEERING, additional sketches of deceased members have been coming in from time to time. As fast as these are prepared and edited, they are put in print, so that separate pamphlets are now available covering the memoirs of the following Society members:

Albert Ross Bailey
William James Boucher
Hector Robins Burroughs
St. John Clarke
Henry St. Leger Coppée
Frederic Clark Dunlap
Preston Burt Easterbrooks
James Harvey Edwards
Benjamin Hurt Hardaway
William Chaffin Howe
Thomas Rogers Hughes
Edgar Jadwin
Frank Burdette Kiel
Horace Miller Marshall
William Lawrence Saunders
Anton Schneider
Lester Waldo Tucker
John Simpson Walker
Samuel Houston Ware
Ferd Clark Wintermute
Elmer Zarbell

To judge by the number of requests, following the appearance of the previous list, it is evident that members are interested in obtaining these historical accounts of old friends prior to their formal appearance in TRANSACTIONS. Copies of any of the memoirs here listed, or of those previously announced, are available upon request to Headquarters.

Research on Earths and Foundations

Of late years increasing interest is being shown in the matter of soils, soil mechanics, and kindred topics. Many engineers and many organizations have devoted both time and effort to this study, including several groups within the Society itself. Among the latter is one of the technical committees of the Society, that on Earths and Foundations.

Plans have been laid and actual progress is being made on two lines of endeavor, which are independent in scope and widely separated in actual physical performance. These activities, as announced by the committee itself, may be briefly summarized in the following condensed outline.

First, there is the work being done under the direction of Glennon Gilboy, Jun. Am. Soc. C.E., at the Massachusetts Institute of Technology. It consists in the compilation of information on soil mechanics in a form available to engineers, and includes the following elements:

1. Layout of program of soil analysis through laboratory testing of bearings
2. As a corollary, the value of pile foundations in alluvial deposits, including proper spacing of piles, the value of one pile compared to a group, and related factors
3. Determination of the reactions recurring in the soil beneath spread footings, including shape of footings, relative bearing value of small versus large footings, and similar elements.

For the second series of studies, we must turn to Vienna, Austria, where Charles Terzaghi, M. Am. Soc. C.E., is conducting extensive work along the following lines:

1. Observations on a steel water tank with flexible bottom to determine for a large area the distribution of pressure on yielding soil
2. Keeping accurate records of the behavior of buildings erected on soft strata in Europe
3. Keeping in touch with the developments of soil mechanics and knowledge of foundations throughout Europe.

Results of this work are expected to be made public in a progress report of the Committee on Earths and Foundations. In addition to the research projects mentioned, this progress report is also expected to deal with:

1. Outline of method of taking undisturbed soil samples by borings.
2. Physical testing of such samples for compressibility, porosity, and similar characteristics
3. Recent results of microscopic investigations of incompletely consolidated clay
4. Outline of practical method of determining the various zones of pressure beneath a structure founded on compressible material
   (*a*) Prediction of the settlements in alluvial soils and wet clays.

In view of the widespread interest in this work, many engineers will await announcement of the results with interest. The committee, of which Lazarus White, M. Am. Soc. C.E., is chairman, has approached its problems with a desire to accomplish something of value and its findings should therefore command increased attention among engineers.

Official Nominees for 1932

Recent action regarding nominations for Society officers for the ensuing year has completed the Constitutional requirements covering these details. The Nominating Committee of the Society met in St. Paul on October 5, and the second ballot for official nominees was canvassed at Headquarters on October 15. As a result, the list of official nominees for officers for the coming year, 1932, is now completed. It comprises the following:

For President, Herbert S. Crocker, M. Am. Soc. C.E., of Denver, Colo.
For Vice-President, Zone I, Arthur S. Tuttle, M. Am. Soc. C.E., New York, N.Y.
For Vice-President, Zone IV, D. C. Henny, M. Am. Soc. C.E., Portland, Ore.
For Directors:
District 3, E. P. Lupfer, M. Am. Soc. C.E., Buffalo, N.Y.
District 5, John H. Gregory, M. Am. Soc. C.E., Baltimore, Md.

District 7, H. E. Riggs, M. Am. Soc. C.E., Ann Arbor, Mich.
District 8, M. L. Enger, M. Am. Soc. C.E., Urbana, Ill.
District 9, Robert Hoffmann, M. Am. Soc. C.E., Cleveland, Ohio
District 12, J. C. Stevens, M. Am. Soc. C.E., Portland, Ore.
District 16, E. B. Black, M. Am. Soc. C. E., Kansas City, Mo.

In due course, every corporate member will receive a blank ballot for his final vote. These in turn will be canvassed next January, and the results will be announced just prior to the installation ceremony on Wednesday morning, January 20, during the course of the Annual Meeting.

Question in Professional Conduct Answered

The following hypothetical question of professional conduct was submitted to the Board of Direction at St. Paul, by the Committee on Professional Conduct.

Two engineers, "A" and "B" were assigned to adjust a contractor's claims for extras. They disagreed in the amount to be allowed the contractor, engineer "A" favoring a smaller amount, and engineer "B" favoring a larger amount.

A third engineer, "C," was engaged as referee. Engineer "C" reviewed the work on the ground and heard the contractor and other advocates of his claim in the presence of engineer "B" (the one who had found favorably for the contractor) without allowing engineer "A" (who had found less favorably) an opportunity to be present or to be heard.

Question: Was this ethical practice on the part of engineer "C," the referee?

The Board confirmed the opinion of the committee that engineer "C" did not act in an ethical manner.

Men Available

When members hear of vacancies in engineering positions or when inquiries of this nature are addressed to them, one source of information should immediately flash to their minds. A condensed list of men available appears in the back part of every issue of CIVIL ENGINEERING. That is the logical place to answer such questions.

These are selected men; and never has the quality or extent of choice been better. For convenience, their experience is briefly stated so that little chance for misunderstanding should exist. When occasion offers, a study of this list will be found profitable.

Forward-Looking Program for Employment of Engineers

By authorization of the Board of Direction at its October 5–6 meeting, steps are being taken to attack some of the current difficulties in engineering employment on a countrywide scale. The occasion for these developments and the scope proposed are best explained by a report submitted to the Board from E. P. Goodrich, M. Am. Soc. C.E., Chairman of the Society's Committee on Salaries. This report presents the situation and suggestions for its solution, as follows:

"An extended discussion of the present unemployment situation would be but 'an elaboration of the obvious.' What has been obvious in other walks of life has lately been thrust home acutely in the civil engineering profession. It is estimated that at least 15 per cent of civil engineers are out of employment. Of that number, at least 10 per cent are in straitened circumstances and are worthy of assistance. It is with reference to those worthy engineers that the following is suggested.

"The Committee on Salaries believes that measures of relief should be planned at once—first of an immediate nature, and later of a more comprehensive type. Those measures might, to some extent, ameliorate the impending 'liquidation in wages' which many fear.

"The Committee, therefore, presents for your consideration a program for the immediate relief of unemployed engineers which it is proposed be approved by the Board of Direction, and put into effect in their respective localities by the Local Sections of the Society or other groups. It is a program believed to be attainable in a high degree.

Program for the Relief of Unemployed Engineers

"(*a*) The creation in each locality of an organization committee of engineers
"(*b*) The collection by them of funds among employed engineers and others, for purposes of loan and remuneration
"(*c*) A survey of the local engineers, unemployed and in need of relief
"(*d*) A survey by such engineers of local opportunities for 'made-work' on which there can be utilized the much greater group of unemployed which are to be supported through the use of a community unemployment fund
"(*e*) The preparation by those unemployed engineers of engineering analyses, estimates, and organization requirements for each project
"(*f*) The forceful presentation of such projects by the committee of engineers, to those in charge of the local civic unemployment activities.

"It is recommended that the program be approved; that the Local Sections be urged each to adopt it for application in its own locality; and that this Committee be directed to use its unexpended appropriation to further the adoption and execution of the program in as widespread a degree as possible."

Impressed with the significance of this proposed program, the Board enthusiastically adopted it. Thereafter, events took place rapidly. Under date of October 8, all Local Sections were advised of this action. On its part, the Metropolitan Section of the Society has already accepted the responsibility of pushing the project and has invited the metropolitan sections of the other societies to join with it in this work. An organization has been perfected by a steering committee to handle the local problem, involving not only New York City but the New Jersey and Westchester County districts as well.

Meeting at Headquarters on October 21, this group adopted for its name the "Professional Engineers Committee on Unemployment." In operation, its work will be handled by three committees, the Executive Committee and the Finance Committee, whose functions are obvious, and the Relief Committee, whose duties may be somewhat elaborated.

One part of the work of the Relief Committee will be carried on by a Subcommittee on Vital Statistics, whose function it will be to make a survey of the financial needs of the unemployed. Next comes the Subcommittee on Plans, whose duty it will be to act on behalf of the community in discovering and analyzing projects suitable to provide work for the unemployed in general. Still another Subcommittee on Opportunities in Business and Industry will round out the work of the Relief Committee.

Much interest attaches to these efforts. Reports covering the development of the Committee's methods and their success in operation will be anxiously awaited. It is understood that the same idea in nucleus form has found favor in Chicago, where local sections of the four Founder Societies and of the Western Society of Engineers are collaborating.

Student Chapters—Attention!

Since announcement was made of the lantern lectures available for the present season, inquiries have been coming in at a gratifying rate. Before this issue of CIVIL ENGINEERING reaches its readers, 19 lectures will already have been given, and reservations are on file for at least 45 others, some of the dates being as late as May 1932.

All 13 lectures have been engaged by one Chapter, and 12 of the series by another Chapter, neither of which took advantage of this service last year. On the other hand, reservations have been made by those who used a number of titles in the past year and found them so valuable that they wish to have the same material again for the new classes.

Look up the list on page 1211 of our October issue, and send in your requests.

A Preview of Proceedings

First place in the November issue of Proceedings will be given to a valuable paper an the practical application of a theory for designing dams to resist earthquake stresses. In addition, there will be included two papers describing widely differing phases of highway construction, the results of developments in the West, which highway engineers will be sure to find of interest.

WATER PRESSURE ON DAMS DURING EARTHQUAKES

Technical literature does not contain much information on the subject of earthquake stresses in dams, and few of these structures have been designed to take into account the extra water load that may be exerted during seismic disturbances. The analysis

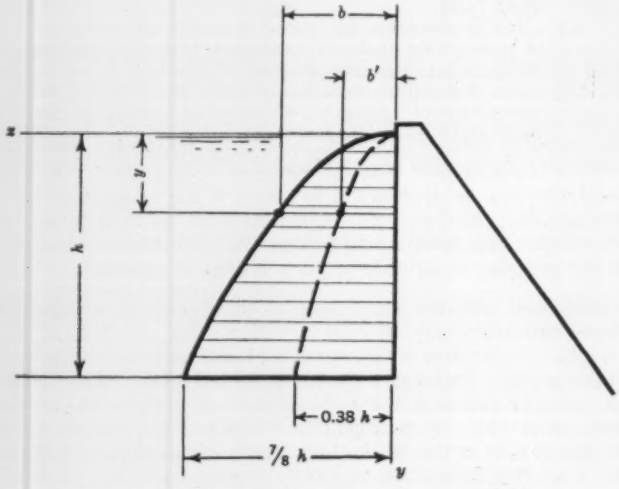


FIG. 1. SHAPE OF MOVING BODY OF WATER
Dotted Parabola Outlines Its Equivalent in Concrete

presented by H. M. Westergaard, M. Am. Soc. C.E., Professor of Theoretical and Applied Mechanics at the University of Illinois, was developed by him in connection with the design of Hoover Dam. To the ordinary stresses in a concrete dam, the action of an earthquake will add other stresses, caused first by the acceleration of the mass of the dam and, second, by changes in water pressure.

It is the second of these extraordinary loads that, according to Professor Westergaard, needs special attention. He has developed formulas to express the changes in water pressure that occur during an earthquake on a straight dam with a vertical upstream face. The earthquake vibrations are assumed to be horizontal in a direction perpendicular to the face of the dam. A satisfactory approximate equation is also presented for use. From one point of view, the pressure may be considered the same as if a definite body of water were forced to move back and forth with the dam, while the remainder of the water in the reservoir is undisturbed. The shape of this moving body of water is shown in Fig. 1, by the shaded area within the parabola. The dotted parabola indicates the equivalent amount of concrete by weight.

LOW COST, BITUMINOUS-TREATED, SECONDARY ROADS

In his paper on "Low-Cost, Bituminous-Treated, Secondary Roads," Walter N. Frickstad, M. Am. Soc. C.E., City Engineer of Oakland, Calif., a close student of this subject, summarizes the trend in surface treatment practice up to the end of 1929, and amplifies the developments from that time to date, with special emphasis on the eleven most westerly states. Declaring that methods in any section have not yet become standardized, the author outlines the processes of surface treatment in various states, particularly in California and Oregon. The oil-mixing process, by which the asphalt binder is thoroughly incorporated with the upper two, three, or even four inches of surfacing material, is described in this paper. According to Mr. Frickstad the oil and aggregate may be mixed at the plant or directly on the road, and each method has certain advantages and disadvantages, which he discusses. He devotes considerable space to the subject of grading aggregates and of proportioning oil to them for the best results. He also comments on the relative merits of asphaltic oil from the Rocky Mountain area and from California, pointing out that un-

USUAL EQUIPMENT FOR MIXING ROAD SURFACES IN THE FIELD
Oil Spreader, Tractor-Drawn Harrow, and Three Blades

doubtedly oils differ in their suitability and that a strong effort should be made to ascertain the reason in each case. In conclusion, Mr. Frickstad explains that although oil treatments have never been seriously proposed as a substitute for the standard high types of pavement, they are actually encroaching upon that field to some extent, especially in cases where freedom from dust and convenience to travel are dominant features in making a choice. Thus, he says, oil treatment is finding its place, mainly at the expense of the lower types, but to some degree as a substitute for the higher.

WESTERN HIGHWAY PRACTICE WITH ESPECIAL REFERENCE TO CALIFORNIA

From the highway engineer's point of view, the paper by C. S. Pope, M. Am. Soc. C.E., Construction Engineer, California Division of Highways, Sacramento, on "Western Highway Practice with Especial Reference to California," is unusual and deals with unusual problems. After commenting briefly on the financing aspect of highway administration, the author takes up the subject

HEAVY CLEARING IN REDWOOD FORESTS
Highway Right-of-Way in Northern California

of clearing rights-of-way for highways in California. However, the main purpose of the paper is to describe the construction of work to protect highways from the elements, such as floods, cloudbursts, earthquakes, erosion, and wind-blown sand. Unit costs for such construction form an important and interesting part of the paper.

FLOOD PROTECTION DIKES AND CHANNELS USED IN DESERT REGIONS

Cloudbursts Necessitate Careful Attention

The subject, with which Mr. Pope is very familiar, was presented by him before the Highway Division of the Society at its meeting in Sacramento, in April 1930. That presentation was abstracted briefly in the August 1930 number of PROCEEDINGS, and the forthcoming paper is intended to summarize the very latest developments in this field.

News of Local Sections

CENTRAL OHIO SECTION

A luncheon meeting of the Section was held on September 17, with both members and guests in attendance. A very interesting talk on new types of precise surveying instruments and an exhibition of a Wild theodolite and a Zeiss level were given by Prof. Edwin F. Coddington, of the Civil Engineering Department of Ohio State University.

GEORGIA SECTION

The Georgia Section held its September meeting at the Atlanta Athletic Club on Monday, August 31, with James A. Higgs, President, in the chair. Presenting his paper "Foundation Conditions in Atlanta and Vicinity," William C. Spiker, a member of the Section, covered the subjects of materials for foundations, the bearing capacity of various soils and rocks, and the different types of footings. In discussion, F. C. Sturmer described the 152 open caissons which he has recently put down in Atlanta and particularly pointed out that it was more economical to vary the strength of the mixture of the concrete in these caissons than it was to vary their diameters. Other discussions were presented by Robert G. Lose and Herbert Oliver.

LOS ANGELES SECTION

A meeting of the Los Angeles Section was held on September 16 at the City Club. Following the dinner, Julian Hinds, Chief Designing Engineer of the Metropolitan Water District, gave an interesting talk on the necessity of the proposed Colorado River Aqueduct. An enlightening and forceful lecture on "The Engineer's Part in Regional Planning" was then given by William J. Fox, who is well known for his work in connection with regional planning throughout the county. This was followed by a paper read by Donald M. Baker, former President of the Los Angeles City Planning Commission, on "Mass Transportation and Its Related Problems."

Prior to this meeting, the Junior Forum met and was addressed by John M. Server, Jr., on "Interesting Facts of Death Valley."

The series of fall meetings of the Sanitary Group of the Section started with a meeting on Wednesday night, September 30. The Chief Chemist of the Wallace and Tiernan Company, Dr. Baker, gave a short talk on recent experiments made by that company in the development of new equipment. Then W. A. Allen, Assistant Operator of the Pasadena Sewage Treatment Plant, gave a description of several Eastern plants, their operating methods, and results, and R. F. Goudey, Sanitary Engineer, Department of Water and Power, City of Los Angeles, gave an illustrated lecture on plants in the East.

METROPOLITAN SECTION

At the first fall meeting of this Section, held in New York on October 21, the engineering features of the new George Washington Bridge formed the subject of an interesting series of addresses. This was particularly appropriate in view of the official dedication of the structure three days later. The discussion was led by O. H. Ammann, M. Am. Soc. C.E., Chief Engineer, Port of New York Authority, who gave a review of the "Major Economic and Engineering Questions." Following him, Arthur S. Tuttle, M. Am. Soc. C.E., spoke on the "New York Approach"; Jacob L. Bauer, M. Am. Soc. C.E., treated the "New Jersey State Highway Connection"; and M. B. Case, M. Am. Soc. C.E., discussed the "Major Construction Problems." Some unusually good lantern slides and several fine reels of motion pictures aided materially in clarifying these talks. The meeting was then adjourned and refreshments were served. The attendance, which taxed the accommodations of the fifth floor of the Engineering Societies' Building, totaled about 700.

NEBRASKA SECTION

At the June meeting of the Nebraska Section, the following officers were elected for the coming year: Theodore A. Leisen, President; John Glenn Mason, Vice-President; and R. E. Edgecomb, Secretary-Treasurer.

NEW MEXICO SECTION

The first fall meeting of the New Mexico Section was held at Albuquerque on Wednesday evening, September 23, at which time H. L. Thompson gave a talk on "Structural Timber." This was a summary of studies in lumber for irrigation structures made by the Designing Department of the Middle Rio Grande Conservancy District.

PORTO RICAN SECTION

At the meeting of this Section held on September 19, two technical papers were read—one on "Water-Cement Ratio" and the other on "Flood Control for Ponce City." On September 20, the members went to Central Fajardo on an inspection trip of drainage and railroad construction work.

SACRAMENTO SECTION

Weekly meetings of the Sacramento Section were held during the past summer. Among the speakers at these various meetings were: Joseph E. Spink, Engineer of the American River Flood Control District; H. M. Engle, of the Board of Fire Underwriters of the Pacific Coast; E. Court Eaton, Chief Engineer of the Los Angeles Flood Control District; Frank E. Howell, of the Great Northern Railway; W. B. Hogan, City Manager of Stockton; Everett N. Bryan, Henry D. Dewell, and Charles Francis Pope.

The 400th regular meeting of the Section, held on July 7, was addressed by Prof. George E. Beggs, of Princeton University, who is a consultant on the San Francisco Bay Bridge now being designed.

On July 13, President Francis Lee Stuart read a portion of his Tacoma address on "Engineers' Growing Civic Responsibilities," and on September 8, motion pictures of the "Tipping of the Chute à Caron Precast Dam into Place" were shown.

ST. LOUIS SECTION

The speaker of the day at the September Meeting of the St. Louis Section was H. J. Pfeiffer, Chief Engineer of the Terminal Railroad Association of St. Louis, who gave an interesting talk on the $5,000,000 Mart Building now nearing completion. This was the Section's first meeting after the summer vacation, and there were about 40 members present.

TACOMA SECTION

The Tacoma Section, at its September 14 dinner meeting, had C. S. McCormick, Structural Designer and Building Inspector of the City of Tacoma, as the speaker of the evening. His subject was "The Uniform Building Code" as prepared by the Pacific Coast Building Officials Conference.

ITEMS OF INTEREST

Engineering Events in Brief

Professor Suyehiro Lecturing on Seismology

AMERICA is being accorded an unusual privilege in being permitted to hear a notable authority on seismology, Professor Kyoji Suyehiro. As Director of the Earthquake Research Institute of the Tokyo Imperial University, he easily leads Japanese authorities on earthquakes. One engineer, who knows whereof he speaks, has characterized Professor Suyehiro as "the foremost man in all the world in devising practical methods of research for safeguarding human life and property from earthquake damage."

It is therefore with unusual gratification that the Society has been instrumental in securing the attendance of this noted engineer to give a series of talks throughout the United States. He arrived in San Francisco on October 21 and immediately began his work by delivering an address the following evening before local members of the Society, together with those of the Seismological Society of America. For the immediate future, his itinerary will keep him in California, speaking before the Commonwealth Club of San Francisco, then giving a series of lectures at the University of California, and later lecturing at Leland Stanford Junior University and, early in November, at the California Institute of Technology in southern California.

Detailed arrangements for the following weeks are still in the course of formulation after conference with Professor Suyehiro. It is expected, however, that he will devote considerable time to lectures and conferences in Washington, D.C., going from there to New York City for another visit of a few days and finally, toward the end of the month, for a series of lectures at the Massachusetts Institute of Technology in Cambridge, Mass.

Inasmuch as detailed arrangements are subject to revision at the convenience of the visiting lecturer, members who desire an opportunity to listen to him should keep in touch with their local Society officers. Such opportunity is one which cannot be lightly dismissed.

Behind this visit are several thoughts which have guided in the formulation of the arrangements. Professor Suyehiro's experience and training have given him a wonderful command of the entire subject in all its ramifications. It is expected, however, that he will emphasize in particular the engineering aspects of earthquakes rather than those relative to geophysics. To members, therefore, his lectures will have a distinctly practical value. In this connection, it is to be remembered that the Japanese during recent years have had occasion to refine to an intense degree these same practical developments.

A second element in this visit is its value as an expression of international friendship. Americans have had frequent opportunities to listen to foreign lecturers, especially from across the Atlantic, but it is seldom that leaders in scientific thought from beyond the Pacific have been heard.

Just what may be the content of the lectures to be delivered is a matter entirely in Professor Suyehiro's hands. Doubtless it will vary somewhat according to local conditions; it is expected, however, that he will cover many or all of the following points:

1. The types of earthquake research most useful to structural engineers as exemplified by his experience in Japan
2. The apparatus with which these researches can most efficiently be conducted
3. The nature of the present programs of earthquake research in Japan, including what has already been accomplished or found out by means of them
4. Suggestions from Japanese experience as to the precautions which should be observed in earthquake-resisting construction.

One factor which has delayed Professor Suyehiro's visit, but which will add interest to his lectures, is the occurrence, last November, of a serious earthquake in the Province of Idu, Japan. Although local in character, it occasioned the loss of 260 lives. The important feature in connection with it, however, was the presence just beneath the most disturbed area of a long railroad tunnel, of which four miles had been already finished. In alignment, this tunnel was directly perpendicular to the fault line so that it became possible to obtain three-dimensional investigations of the ensuing crustal movements, for the first time in the history of seismology. These and many other interesting developments will doubtless form important parts of his addresses.

It is hoped and expected that this visit with its attendant series of lectures will constitute an outstanding event in American engineering annals. The Society has been instrumental in conducting the various inquiries and making general arrangements. Members at the various localities in which Professor Suyehiro will stop, are making the local plans for his visit. In particular the profession is indebted to John R. Freeman, Honorary Member Am. Soc. C.E., through whose active interest and good offices American engineers have been privileged to welcome this distinguished foreign visitor.

COMING EVENTS

AMERICAN SOCIETY OF CIVIL ENGINEERS

Annual Meeting Convenes in New York

January 20, 21, 22, 1932

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Annual Meeting, New York, November 30–December 4

AMERICAN WATER WORKS ASSOCIATION
North Carolina Section. Joint Annual Meeting with the North Carolina Sewage Works Association, Greensboro. November 2–4

CONFERENCE ON METALS AND METAL ALLOYS
Case School of Applied Science, Cleveland, November 18, 19, and 20

FIRST NATIONAL EXPOSITION OF MECHANICAL HANDLING
New York, November 30–December 5

INTERNATIONAL CONFERENCE ON BITUMINOUS COAL
Carnegie Institute of Technology, Pittsburgh, November 16–21

IOWA SEWAGE TREATMENT CONFERENCE
Ames, November 12–14

NORTH DAKOTA WATER AND SEWAGE WORKS CONFERENCE
Annual Meeting, Fargo, November 5–7

VIRGINIA WATER AND SEWAGE WORKS ASSOCIATION
Annual Meeting, Lynchburg, November 16–17

Bids for Engineering Services

AN EDITORIAL in the October issue of *The American City* stresses the fact that an initial "saving" in obtaining professional services often results in a higher final cost for the work. Deploring the sporadic instances in which engineering services have been sought on a competitive basis, it gives as a desirable alternative the following five pointers for use by city officials in selecting competent consultants:

1. A city wishing to secure a consultant for a specific piece of work should make inquiries of disinterested and qualified persons for the names of consulting engineers whose education and experience qualify them for the work contemplated. These inquiries should be addressed to the editors of national technical journals, to the professional bureau maintained by the national engineering societies with headquarters in New York City, and to officials in other cities where similar work has been completed.
2. Upon securing the names of a few qualified consulting engineers, the city officials should interview the engineers, look over their offices to determine the character of their organization, and, through discussions with them, determine each engineer's personal qualifications for the work.

3. The officials should secure a record of the education and experience of each engineer, with references.

4. The officials should satisfy themselves by letter inquiry and by visits to some of the engineers' work, as to the truth and quality of the records furnished by the engineers.

5. Finally, an agreement should be made with an engineer for the required service at reasonable terms. Reference should be made to the pamphlet, "Charges for Engineering Service," published by the American Society of Civil Engineers, 33 West 39th Street, New York, which discusses in detail, for the benefit of clients, reasonable fees for various types of engineering services.

National Electrical Code Approved

THE American Standards Association, of which the Society is a member, is so organized as "to provide systematic means of cooperation in establishing American standards to the end that duplication of work and the promulgation of conflicting standards may be avoided; to serve as a clearing house for information on standardization work in the United States and foreign countries; and to act as the authoritative American channel in international cooperation in standardization work."

The association has just approved of the 1931 edition of the National Electrical Code. This code was submitted by the National Fire Protection Association, who are sponsors for the sectional committee in charge of the revision of the code under the procedure of the American Standards Association. A first edition of 200,000 copies is being printed by the National Board of Fire Underwriters, and copies will shortly be available through the board's offices in New York, Chicago, and San Francisco, or from the headquarters of the American Standards Association, 29 West 39th Street, New York, N.Y.

This new edition represents the 15th revision of the original National Electrical Code as it was first published in 1897. The committee, in whose hands the revision rests, includes 43 technical representatives of 26 national, state, and local associations, and inspection departments and other organizations. In fact, it represents a complete cross section of the electrical industry in so far as that industry is concerned with the scope of the code.

Included in the scope are "requirements for the installation of electrical wiring and equipment for light, heat, and power, as they affect the fire hazard, and for signaling systems, so far as they may involve such hazard." The code also includes "equipments affecting the life hazard in numerous applications and uses."

While, in general, the majority of the changes in the code are of an editorial nature, important new material has also been added. For example, a new section of Article 34, Motion Picture Studios, covering wiring in connection with sound recording and reproduction has been included for the first time.

An analysis of the 1931 revision of the National Electrical Code, containing in detail all of the differences between the 1930 and the 1931 editions, has been published by the National Electrical Manufacturers Association, as publication Number 31–11, August 1931. This material is for sale at the offices of the National Electrical Manufacturers Association, 420 Lexington Avenue, New York, at ten cents a copy.

The Story of the Homestake Pass, Discovered in 1889

AN ITEM in the October issue noted the death of Edwin H. McHenry, M. Am. Soc. C.E., in August of this year and his interest in engineering research, as indicated by the generous provisions in his will. During the period (1895–1896) when the receivership of the Northern Pacific Railroad was in the hands of Mr. McHenry and F. G. Bigelow, technicalities caused Mr. McHenry simultaneously to hold the position of receiver in two receiverships; that of president and vice-president in 26 companies; and of director in 52 subsidiary companies; while at the same time he was Chief Engineer of the Northern Pacific Railroad, and Acting Insurance Agent, Right-of-Way Agent, and Lease Agent—a rather striking array of official positions. For legal reasons the title to the Northern Pacific Railroad property was conveyed to the receivers directly and by them reconveyed to the new company, the Northern Pacific Railway Company. The reconveyance required the signature of but one of the receivers, and in the parlors of J. P. Morgan and Company, Mr. McHenry in 1896 signed the deed to $355,000,000 worth of property, which the company now holds by reason of that signature.

In line with the desire of the Committee on Publications to encourage the publication in these columns from time to time of interesting experiences in the lives of engineers, the following quotations are abstracted from a narrative prepared by Mr. McHenry, and presented in 1925 before the Montana Society of Engineers. The Committee will be glad to receive and consider similar reminiscences from readers.

"Impelled by the impending competition [of the Great Northern Railway], the Northern Pacific felt the need for a better eastern route from Butte.... I set out for the exploration of the Pipestone Pass February 3, 1889, from the headquarters camp at Three Forks, Mont., riding 'Buck,' my favorite buckskin pony, following up the course of the Jefferson River through the so-called 'Little' and 'Middle' canyons to the camp of the locating party at work on the line to Boulder, and later in the day continued up the main canyon, putting in the night at Sacry's Ranch, at the mouth of the little Boulder River. There was no trail through the canyon and several rather dubious detours were necessary at difficult points on the broken ice of the frozen river. My pony liked these detours even less than I did and was visibly relieved when each passage was safely concluded....

"About this time vague rumors came to my ears of another and more northerly pass reported by some prospectors, which was said to afford a shorter line to Butte, but I was more annoyed than impressed by the information, thinking that it was only one of the many ghosts of the kind so familiar to Western locating engineers, but nevertheless felt obliged to run down the rumor if for no other purpose than to dismiss it as a possibility....

"I had hoped to meet John Paul [at his ranch near the present station of Whitehall] who, I had been told, could give me the best information concerning the possible existence of any passes through the main range north of the well known Pipestone Pass....Stopping overnight at the ranch house, I went on next morning to the Hot Springs and was fortunate in meeting Paul there, later in the same day...."

A WOODCHOPPER'S TRAIL

"Paul confirmed the existence of a little known pass and gave me so much encouraging information concerning its features that I began to hope that it might be practicable for a railroad route, and then decided to explore it—before reexamining the Pipestone Pass, as first intended—and was glad to take up his offer to make the trip with me as guide, which would obviously avoid much uncertainty and loss of time.

"In response to my expressed doubt as to the probability of the existence of an unknown pass in such close proximity to Butte, he explained that its approaches were so rocky and difficult and its western slopes so steep that none but prospectors had used it until quite recently—when some woodchoppers had come in from the west—and that for these reasons very few others knew of its existence.

"It was not indicated on any maps of the region and had not been given even a local name.

"Paul further added that some time previously he had worked out a trail 'joining up' with one of the woodchoppers' roads near the summit, with the expectation of eventually securing a better and shorter road from Butte to his property at the Hot Springs, believing that such a road would increase its value. He had no knowledge of any previous engineering examination of the pass and did not believe that one had been made...."

FIRST ENGINEERING EXAMINATION IN 1889

"We made an early start for the summit from the Pipestone Hot Springs on the morning of February 6, 1889, making the first part of the ascent along Big Pipestone Creek, which in turn was followed down to Homestake Creek, and thence up a lateral and steeper valley nearly paralleling and south of the much deeper canyon of Homestake Creek; to its 'divide' with one of the smaller tributaries of Homestake Creek, which in turn was followed down to its junction with the main creek near

Dead Woman's Ranch, located about one and one-half miles east of the pass we were then seeking. The trails had not been traversed since the advent of winter and the deep snows encountered in the thick forests of lodge pole pines on this part of the route, made progress both slow and difficult for our horses. There was less snow on the last two miles of the ascent, as the growth of timber was sparser and much of the snow had melted from time to time during the winter....

"We reached the pass in the continental divide which we were seeking about the middle of the afternoon. The elevation of the pass was found to be 6,323 ft. above sea level, and the pass itself was not at all impressive in appearance, being little more than an obscure notch in the main range, which is hidden from view from the Black Tail Valley on the west by a short overlapping spur, and its difficulties were all in its approaches, which is a rather common condition in mountain locations. Having been informed by John Paul that the pass as yet had no distinguishing name, in my subsequent report I provisionally called it the 'Homestake Pass,' from the stream of the same name which heads near the pass, which name was later confirmed and universally used thereafter...."

VERY ROUGH APPROACHES

"The opportunities for observation were necessarily limited on such a hasty reconnaissance but with the aid of barometrical elevations and estimated distances, certain tentative conclusions could be reached with a fair degree of certainty. Easterly from the summit for the first two miles the average grade of Homestake Creek closely approximated 116 ft. per mile (2.2 per cent) which is a standard mountain grade and hence the opportunities for effecting any very material reduction of the summit elevation by tunneling were economically very much restricted....

"On the western side of the pass, the slopes were very precipitous, dropping 800 ft. in three quarters of a mile to the upper 'bench' of the Black Tail Valley. There was, however, ample distance in which to make the descent before the crossing of Silver Bow Creek was reached and accordingly there were no location problems to be solved on this side of the mountain, apart from the difficulties introduced by the excessive roughness of the slopes, which is a characteristic feature of the granite formation of this general region. This condition was very marked in the Homestake Canyon, on the eastern slope of the mountain, which later taxed both the physical and trigonometrical powers of the engineers to their utmost in fixing and marking the line of definite location through the wild and tangled mass of huge boulders, timber, and brush as then encountered...."

MORE ECONOMICAL THAN PIPESTONE PASS

"My ultimate findings regarding the comparative merits of the two passes, based upon the later surveys, may be briefly summarized by saying that differences were found in favor of the Homestake route, of 75 ft. in summit height, 5 miles in distance, $100,000 (more or less) in cost of the roadbed, and about $500,000 in economic values, based upon a very moderate number of daily trains, which has long since been exceeded....

"My report was written and given to my chief, Mr. W. A. Haven [M. Am. Soc. C. E.] on the day of my arrival at Helena, by whom it was forwarded to the Chief Engineer at St. Paul, together with his favorable endorsement.

"It rarely falls to the lot of an engineer to secure such quick action upon his recommendations as it was my good fortune to obtain on this occasion. Orders were soon received to organize additional parties to be sent to both the Pipestone and Homestake Passes, which was done, and in March the preliminary surveys were begun; in April, the surveys had progressed far enough to conclusively indicate the superiority of the Homestake route, whereupon the survey of the Pipestone route was discontinued and all parties on this survey were then transferred and concentrated upon the speedy completion of the Homestake line. In May, the final location was begun, and in June construction was initiated in advance of the completion of the location by the firing of the first blast near the summit."

FIFTEEN MONTHS FROM DISCOVERY TO TRACK CONNECTION

"Eleven months later (May 1890) the tracklayers from the east and west ends at Logan and Butte had met and completed the track connection at a point on the east side of the mountain, near Beef-Straight Rock.

"Between the dates of the discovery of the pass and the final track connection, but little over 15 months had been required—for the exploration of the two passes, all preliminary and location surveys, and the heavy work of construction—which at least was an unusual record, in which I took no little pride at the time and am still glad to remember."

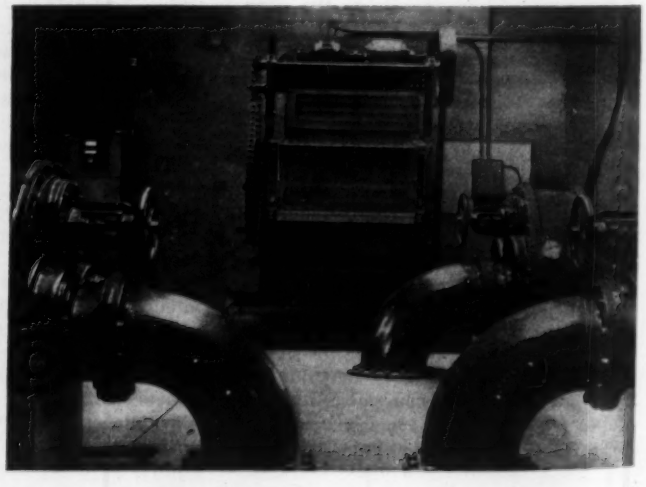
Chicago's Lake Front Park Has Special Water System

GRANT PARK and the site of the Century of Progress Exposition, Chicago, was originally but a narrow strip of land reclaimed from Lake Michigan by filling in with excavated materials, extending along the lake front from Randolph Street to Roosevelt Road. The extension to Jackson Park, a distance of more than 7 miles along the Illinois Central right-of-way, was all under the waters of Lake Michigan.

Some years ago a comprehensive plan for the development and extension of this park was undertaken by the South Park Commissioners, the Chicago Plan Commission assisting in the preparing of the plans. This plan included the reclamation of hundreds of acres of land from the lake; the laying of walks and driveways; and the building of several notable structures, including the Field Museum, Shedd Aquarium, Soldier's Field Stadium, and the Planetarium. Considerable planting of trees and shrubs, and seeding and maintenance of lawns was required to beautify this land.

As the park grew in extent there was an increasing demand for water for sprinkling purposes, which the existing water mains were not equipped to supply. Consequently the South Park Commissioners

BUCKINGHAM FOUNTAIN IN GRANT PARK, CHICAGO
Century of Progress Exposition



7,000-GAL. PER. MIN. PUMPING STATION ON LAKE MICHIGAN
Traveling Water Intake Screen

built a 7,000 gal. per min. pumping station entirely independent of the city system, for their needs.

This station, built at the lake edge just south of the Aquarium, was put into operation in November 1925, and now supplies water for the sprinkling of lawns and shrubbery throughout the park and fair grounds. Water is taken into the pump house through a heavy bar screen, designed to hold back the driftwood and trash, and then the water flows through a traveling water intake screen, where all of the smaller refuse is removed.

The Buckingham Fountain is among the big users of this water system. Although the water flowing from this gigantic fountain is used repeatedly, that lost by evaporation must be replenished daily. Once a month, during the operating season, the fountain is drained and completely refilled with fresh water. A large amount of water is also being supplied at present in the construction of buildings for the Century of Progress Exposition of 1933.

Radium Shows Defects in Steel

GAMMA rays from radium can be made to shine through steel objects 12 in. thick and reveal their internal defects. Valves for high-pressure power plants and pipe lines can be made safe for use by this means. Battleship parts, such as the sternpost and keel knuckle, can be tested before the trial run is made. Welded parts can be inspected to be sure the welds are sound, and even to check the welding procedure before actual work is begun.

This method of testing reminds one, of course, of the shining of X-rays through thin objects for the same purpose, but it is simpler in some respects, although requiring special procedures in other respects. It is surprising that these gamma rays, known about in general for nearly thirty years, should never have received the proper handling and adaptation necessary to make them serve this useful purpose. Those dealing with radium in the past have been either "pure" scientists, interested only in understanding the nature of "matter" and "energy," or they have been biologists, interested in the therapeutic effects of radium on living organisms.

It remained for a mind trained in the science and art of metallurgy, but working in daily contact with research physicists and their theories of waves and of quanta, to evolve a method for the practical use of gamma rays in inspecting metal objects. These favorable conditions existed at the Naval Research Laboratory in Washington and there a program for developing the gamma ray method was evolved. Nearby, Baltimore had, at the Howard A. Kelly Hospital, a supply of radium. The hospital officials were willing to rent and even lend their radium to the Navy Department for the purpose in mind. Another metailurgist was called in, from Lehigh University, to take charge of the experimental program and carry it out.

Many discouraging prophecies were heard as the plans proceeded. Radium experts in New York City assured the projectors that 5 in. of steel would stop all radiation. The literature likewise, although it described attempts at radiography of the human body by gamma rays, concluded that the results were not satisfactory. The rays would be too short in wave-length to affect a photographic film, at least those rays which had penetrating power; the rays would give no sharp definition on the film, no detail; they would be blurred by the "scattering" of rays from surrounding objects; the danger in handling the radium would be too great; the cost would be prohibitive. These and many other objections and obstacles were advanced, but the work went on.

The principal experimental campaign was concluded in November 1929. Its success was beyond the highest hopes of those interested in the development of the investigation. Clear-cut shadows of defects in the interior of steel objects 8, 10, and even 12 in. thick were registered on the film. Tiny flaws, only 2 per cent of the thickness of the whole object, were clearly revealed.

Practical advantages of the method for examining metal structures was at once obvious. The tiny capsule of radio-active material is so easily transported that it could be carried anywhere—into a submarine, up to the top of a skyscraper, into the machine shop or foundry—anywhere that a large object needed examination. It is not anchored to a laboratory in any way.

Films are simply pasted on to the back of an object and the radium mounted in front of it for the exposure. Of course, suitable films and screens must be used to get the proper result. Later the film is removed and developed to show the shadows cast by the object in the path of the rays. A thousand small objects could be exposed at once by simply placing them in a spherical distribution about the radio-active source.

No large investment in testing machinery, due to become obsolete in ten years or less, is necessary, because radium, the only costly investment, does not decay to half its strength for 1,600 years! The cost of the testing operation is well within reason, if radium can be procured at a fair figure. No risk whatever to the operator is necessary.

Science and invention have placed another bulwark behind the safety of our civilization's structures.

From "Research Narratives," The Engineering Foundation, Inc. Contributed by Gilbert E. Doan, Assistant Professor, Department of Metallurgical Engineering, Lehigh University, Bethlehem, Pa.

References for further reading: "Radiography by Means of Gamma Rays," Mehl, Doan, and Barrett, Proceedings American Society for Steel Treating, September 1930; "Radiography by Means of Gamma Rays," Barrett, Gezelius, and Mehl, Metals and Alloys, December, 1930; "Inspection of Welds with Gamma Rays," G. Doan, Proceedings American Society for Steel Treating, September 1931.

Women's Interest in Engineering Countrywide

EXPERIENCES on both sides of the continent demonstrate conclusively that women are actively interested in engineering work and kindred matters, both because of the sociability involved and the popular appeal of major engineering works. One group of ladies gathered at a luncheon in Tacoma recently to continue the pleasant associations developed at the time of the Society meeting. On the earlier occasion, they had had the privilege of working together on various details in preparation for the Convention, and as a result of their pleasure in this cooperative work, they planned the luncheon, which took place the first week in October. Active in this work were Mrs. Glenn Parker, Mrs. Julian Arntson, and Mrs. F. E. Eastman. This occurrence constitutes one of the pleasant aftermaths of Society Meetings, and should be definitely credited as an added and unexpected advantage resulting from the Meeting.

On the other side of the continent, a somewhat similar group of women has recently enjoyed contact with a large engineering enterprise. This was brought about by the active interest of the Engineering Woman's Club of New York, which arranged for a special inspection trip to the new George Washington Bridge on October 21, just prior to its official opening on October 24. In a sense, therefore, this was an advance showing of this tremendous structure. The ladies were privileged to walk across the structure from the New York side and return, while many of the interesting features were fully explained by engineers of the Port of New York Authority. This same group of ladies previously were among the first to have a demonstration of television. Arrangements for the latest trip were made by Mrs. Frederick C. Noble through the instrumentality of M. B. Case, M. Am. Soc. C.E.

NEWS OF ENGINEERS

From Correspondence and Society Files

LINN HARRISON ENSLOW assumed the editorship of *Water Works and Sewerage* commencing with the October issue. He will continue a part-time connection with the Chlorine Institute, Inc., in an advisory capacity.

JAMES W. FOLLIN has received an appointment as Engineer of the Philadelphia Federation of the Construction Industry. Formerly Mr. Follin was Secretary and Engineer of the Philadelphia Building Chapter, Associated Pennsylvania Constructors.

GLENN B. WOODRUFF is in San Francisco where he has accepted a position as Designing Engineer of the San Francisco Bay Bridge Commission on the trans-bay bridge from Oakland to San Francisco.

C. N. BILLINGS, who was Assistant Division Engineer of the Beaumont Division, Southern Pacific Lines, has recently been transferred to the Victoria Division, as Supervisor of Bridges and Buildings.

GUSTAVE R. LUKESH, now on duty in the New York Engineer District, has been appointed District Engineer of the First New York Engineer District in New York City.

JACOB E. WARNOCK, connected at one time with the Aluminum Company of America, has become associated with the U.S. Bureau of Reclamation in Denver, Colo.

E. T. ROETMAN, formerly of Albia, Iowa, is now a research fellow in Sanitary Engineering at the West Virginia University.

TROY CARMICHAEL, District Manager of the Paving Development and Sales Company, Granville Island, B.C., was formerly District Manager for the Warren Brothers Roads Company of Vancouver.

NICHOLLS WHITE BOWDEN has been appointed a Senior Engineer at the U.S. Engineer Office in Pittsburgh, Pa.

H. H. HAGGARD, until recently with the Cerro de Pasco Copper Corporation of Oroya, Peru, is now affiliated with Sanderson and Porter, of New York City.

HERBERT ERNEST BELLAMY, who in the past has been Government Hydraulic Engineer in Adelaide, South Australia, has moved to Melbourne, Australia, where he is a Consulting Engineer.

ALBERT J. PLATH is now affiliated with the Minnesota State Highway Commission at its St. Paul office.

C. T. WILSON, General Superintendent for the John W. Ferguson Company in Bermuda, is Resident Manager of Colonial Builders, Ltd., an affiliated organization, with offices in the Miles Building, Hamilton.

HOWARD E. BOARDMAN, recently appointed Dudley Professor of Railroad Engineering at the Sheffield Scientific School of Yale University, received this appointment primarily for railroad economic research.

CLARENCE L. WATERBURY is working as a Special Graduate Research Assistant in the Department of Civil Engineering at the University of Illinois. Previously, Mr. Waterbury was connected with Pearse, Greeley, and Hansen of Peoria, Ill.

F. E. FAHY, a former Structural Engineer with Holabird and Root, of Chicago, has become an Instructor of Civil Engineering at Antioch College, Yellow Springs, Ohio.

S. H. CROWELL, who in the past has been a Junior Engineer with the U.S. Geological Survey in Austin, Tex., is now associated with the Fegles Construction Company in Bluffton, Tex.

E. K. MORSE, Consulting Engineer of Pittsburgh, Pa., has been reappointed, by Governor Pinchot, as engineering member of the Water and Power Resources Board of the Commonwealth of Pennsylvania.

P. L. MCLAUGHLIN, previously an Assistant Sanitary Engineer for the Federal Water Service Corporation in New York City, has been transferred to the staff of the Division Engineering Office at Massillon, Ohio.

WALTER N. HARPER is now Assistant to the Principal Engineer, Division Engineers' Office, U.S. Engineer Department. Formerly, Mr. Harper was an Associate Engineer, First New York District, of the same department.

R. HAYES, who was Engineer, Maintenance of Way for the Southern Railway System, has become Assistant Engineer of Bridges.

WALDO E. SMITH recently returned from Robert College, Constantinople, where he was Associate Professor of Civil Engineering, to accept an Assistant Professorship in the same subject at the North Dakota Agricultural College.

F. C. NYLAND, Lieutenant-Commander, C.E.C., U.S. Navy, whose residence has been in Port-au-Prince, Haiti, where he was Officer Engineer in Chief, has recently been transferred to the Norfolk Navy Yard in Portsmouth, Va.

W. N. BROWN and A. F. BROOKE, Washington, D.C., report that they have completed 885 sq. miles of topographic mapping by combination ground and aerial methods. The work was done for the U.S. Corps of Engineers in connection with studies for flood control on the White, Eel, and portions of the Wabash rivers in Indiana.

DONALD P. BARNES, who has been engaged as one of the designers on the Pine Canyon Dam, has resigned to accept the position of Instructor in the Civil Engineering Department of the School of Mines and Metallurgy at the University of Missouri.

ARTHUR SURVEYER has been appointed Chairman of the Chignecto Canal Commission, which was created to look into the question of constructing a canal across the Isthmus of Chignecto from the Bay of Fundy to the Straits of Northumberland. He is a consulting engineer and head of Arthur Surveyer and Company, of Montreal.

EDMUND B. KEATING, Lieutenant C.E.C., U.S. Navy, heretofore Director of Municipal Engineering, Direction Generale de Travaux Publique, in the Republic of Haiti, is now in Norfolk, Va., where he is engaged in the Public Works Office, U.S. Navy Yard.

PHILIP A. WEBER has been appointed Junior Engineer in the U.S. Coast and Geodetic Survey at Washington, D.C.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From September 10 to October 9, 1931

ADDITIONS TO MEMBERSHIP

BAKER, RUSSELL EPHRAIM (Assoc. M. '31), Estimator and Engr., Lovering-Longbothom Co., 605 Builders Exchange Bldg., St. Paul, Minn.

BARNES, HARRY FAIRWEATHER (M. '31), Municipal Engr., British Municipal Council, Tientsin, China.

BAUMGARTNER, JOHN ALBERT (Assoc. M. '31), Asst. Engr., Water Resources Branch, U.S. Geological Survey, Box 1311, Tucson, Ariz.

CHANG, PETER YUN TSIN (Assoc. M. '31), Engr., C. W. Blakeslee & Sons, Inc., 58 Waverly St., New Haven, Conn.

DAVIS, LEROY MILTON (Assoc. M. '31), Engr., Pennsylvania Water & Power Co., Holtwood, Pa.

DAWSON, WENDELL (Assoc. M. '31), Field Engr., U.S. Geological Survey, U.S. Forest Service, Box 1754, Ketchikan, Alaska.

GIDIERE, JOHN JOSEPH (Jun. '31), City Engr., Gretna (Res., 4323 South Roman St., New Orleans), La.

GORDON, MAURICE MILTON (Jun. '30), 2026 Northampton St., Holyoke, Mass.

HAMPTON, SRYGLEY HALL (Assoc. M. '31), Office Engr., City of Flint (Res., 713 Cadillac St., Flint, Mich.).

HATCH, CHARLES EVERETT (Assoc. M. '31), Engr., Lucas County Planning Comm. (Res., 3912 Bowen Rd.), Toledo, Ohio.

HEIL, JOSEPH NORMAN (Assoc. M. '31), with Joint Comm. for Elimination of Toll Bridges over the Delaware River, Pennsylvania-New Jersey, 11 South 2d St., Easton, Pa.

JUDSON, FREDERICK (Jun. '31), Transitman, Board of Water Supply, New York (Res., 7920 Fourth Ave., Brooklyn), N.Y.

LINDNER, CLEMENT PEARL (Assoc. M. '31), 434 Sterling Pl., Madison, Wis.

MARAIS, DAVID FRANCOIS (Assoc. M. '31), Asst. Engr., Dept. of Irrig., Box 86, Cradock, South Africa.

MASON, FAGAN BARB (Assoc. M. '31), Project Bridge Engr., State Highway Dept., Box 2, Temple, Tex.

MELVIN, RAYMOND STUART (Assoc. M. '31), 245 Hillside Ave., Piedmont, Calif.

MOSELEY, DAVID LEIGH (Jun. '31), Airplane Designer, Douglas Aircraft Co., Santa Monica (Res., 2321 Fifth Ave., Los Angeles), Calif.

MURPHY, LAWRENCE PATRICK (Jun. '31), Care U.S. Engr. Office, Peoria, Ill.

PEASE, RAYMOND ALBERT (M. '31), Div. Engr., State Highway Dept., Box 957, Minot, N.D.

REZNOR, RAYMOND KEMPTON (Assoc. M. '31), Dist., Engr., U.S. Fidelity & Guaranty Co. (Res., 2838 Shady Ave.), Pittsburgh, Pa.

RIPLEY, MILLS NORTON (Jun. '31), with Fairchild Aerial Surveys, 270 West 38th St. (Res., 1230 Park Ave.), New York.

STOUT, GEORGE EDWARD (Jun. '31), Box 535, Warren, Pa.

SWEAT, WESLEY ALBERT (Jun. '31), Care, State Road Dept., Lake City, Fla.

TAPPAN, KIRBY HEWITT (Assoc. M. '31), Chf. of Party, Alcoa Power Co., Ltd., Kenogami, Que., Canada.

TSAGARIS, DEAN PETER (Assoc. M. '31), Steel Designer, Stone & Webster Eng. Corp., 49 Federal St., Boston (Res., 139 Templeton Parkway, Watertown), Mass.

VAN HORN, JAMES RAY (Assoc. M. '31), Res. Engr., Highway and Bridge Constr., State Highway Comm., Box 2828, Tucson, Ariz.

WHITEHEAD, RICHARD STANLEY (Jun. '31), 233 Grand Boulevard, San Mateo, Calif.

MEMBERSHIP TRANSFERS

FRAPS, JOSEPH ANTON (Jun. '30; Assoc. M. '31), Engr., State Highway Dept., Phoenix, Ariz.

GODFREY, WILLIAM B. (Assoc. M. '25; M. '31), Supt., Div. of Municipal Eng., Panama Canal, Box 2012, Cristobal, C.Z.

HARDY, CHARLES BAXTER (Jun. '28; Assoc. M. '31), Superv. Engr., Worcester Sewer Dept., 30 Boynton St., Worcester, Mass.

HAWORTH, HARRY SLOAN (Jun. '24; Assoc. M. '31), Designing Engr., Standard Oil Co. (Ind.), 817 Halloran Ave., Wood River, Ill.

HILL, LOUIS HAWES (Jun. '27; Assoc. M. '31), Asst. City Engr. (Res., Holley Ave., South Hills), Charleston, W.Va.

JAÉN GUARDIA, ERNESTO (Assoc. M. '27; M. '31), Chf. Engr., Dept. of Public Works, Box 246, Panama, Panama.

JERAULD, HENRY FRANKLIN (Jun. '25; Assoc. M. '31), Prin. Asst. Engr., Joseph W. Gross, 1029 Forum Bldg. (Res., 1417 Thirty-Sixth St.), Sacramento, Calif.

KEIM, PAUL FERDINAND (Jun. '25; Assoc. M. '31), Instr., Civ. Engr., Univ. of Nebraska, Room 105½ M. A. Bldg., Univ. of Nebraska (Res., 1618 Washington St.), Lincoln, Nebr.

PEARCE, JOHN EDWIN (Jun. '29, Assoc. M. '31), Designing Engr. and Draftsman, Standard Oil Co. of New Jersey (Res., 126 De Hart Pl.), Elizabeth, N.J.

SHAW, EUGENE JAY (Assoc. M. '29; M. '31), Chf. Engr. of Location, Ferrocarril del Pacifico de Nicaragua, Managua, Nicaragua.

VANDERHORST, PAUL MARIE (Jun. '25; Assoc. M. '31), Myers Ave., Denville, N.J.

DEATHS

CRAIGMILE, CHARLES JAMES. Elected Assoc. M., Oct. 14, 1919, M., Mar. 30, 1931; (date of death unknown).

DAWSON, JOHN STANLEY. Elected Assoc. M., June 1, 1920, M., Jan. 16, 1928; died Aug. 6, 1931.

HURRY, EDWARD HENRY. Elected M., June 1, 1898; died Aug. 23, 1931.

KARNER, WILLIAM JOSIAH. Elected Affiliate July 2, 1890; died Sept. 21, 1931.

KIEL, FRANK BURDETTE. Elected Assoc. M., Nov. 25, 1919; died Dec. 31, 1930.

MCCULLOUGH, ERNEST. Elected M., May 31, 1910; died Oct. 1, 1931.

MCLURE, JOHN THOMAS. Elected Assoc. M., Oct. 15, 1923; died Mar. 24, 1931.

MEYERS, MORRIS. Elected Assoc. M., Sept. 10, 1923; died July 26, 1931.

SIMMONS, EDWARD ALFRED. Elected Affiliate Oct. 14, 1919; died Sept. 30, 1931.

SLATER, WILLIS APPLEFORD. Elected Assoc. M., June 24, 1914, M., Jan. 20, 1922; died Oct. 5, 1931.

WILEY, ANDREW JACKSON. Elected M., Dec. 5, 1894; died Oct. 8, 1931.

ZARBELL, ELMER. Elected Jun., Jan. 3, 1899, Assoc. M., Feb. 7, 1900, M., May 5, 1908; died Sept. 10, 1931.

TOTAL MEMBERSHIP AS OF OCTOBER 9, 1931

Members	5,900
Associate Members	6,401
Corporate Members	12,301
Honorary Members	15
Juniors	2,739
Affiliates	131
Fellows	5
Total	15,191

Men and Positions Available

These items are from information furnished by the Engineering Societies Employment Service with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fees is to be found on page 97 of the 1931 Year Book of the Society. Unless otherwise noted, replies should be addressed to the key number, Engineering Societies Employment Service, 31 West 39th Street, New York, N.Y.

Men Available

PATENT ATTORNEY; Assoc. M. Am. Soc. C.E.; desires to organize and manage patent department of corporation; C.E. degree; member New York Bar and U.S. District Bar; registered attorney, U.S. Patent Office; 5½ years with old established firm of patent attorneys; before that 8 years engineering and management experience. Now in charge of patent work for large corporation. B-1819.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 30; married; 4 years experience railroad construction, maintenance large eastern trunk line, also valuation work; 2 years varied experience on flood control project, including work on field surveys, hydraulic investigations and computations, railroad relocation, designs, estimates, and preparation of contract drawings. Available immediately. Location immaterial. C-4993.

FOREIGN SALES REPRESENTATIVE; Assoc. M. Am. Soc. C.E.; roads, buildings, materials, or equipment; for past 7 years representative for leading American asphalt company in India, Burma, and Ceylon; selling tour South and East Africa; 2 years experience railroad engineering in Latin America; 15 years experience in building, construction, and sales work, United States. Employers among best in their lines. B-6364.

CIVIL ENGINEER; M. Am. Soc. C.E.; registered professional engineer, Indiana; B.S. civil engineering, 1913; graduate study, 1913–1914; graduate course in engineering administration and highway engineering at Massachusetts Institute of Technology, 1922. Experience as construction, designing, municipal, and consulting engineer, 1914–1918. Formerly assistant professor and instructor of civil engineering. B-6574.

CIVIL ENGINEER AND EXECUTIVE; M. Am. Soc. C.E.; 25 years experience on important engineering and construction operations, covering water supply, drainage, highways, paving of all classes, municipal and suburban developments, extensive surveys, and financial management. Conference solicited. C-8700.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 29; graduate civil engineer; Michigan license; 7 years varied experience on hydraulic and structural design, including deep shafts and tunnels, pumping stations, power houses, and hydraulic structures, involving difficult foundations and heavy construction. Excellent references. Location immaterial. Available on short notice. C-9870.

EXECUTIVE, CONSTRUCTION ENGINEER, SUPERINTENDENT; M. Am. Soc. C.E.; 37; married; 15 years experience on large hydro-electric projects, on concrete, earth, and rockfill dams, and on all kinds of excavation. In charge of construction, cost estimates, and contract bids. Experience includes power estimates and designs. Employed by large utility contracting companies. United States and foreign locations, including South America. C-9694.

ENGINEERING EXECUTIVE; Assoc. M. Am. Soc. C.E.; 38; technical education; forceful, tactful, cooperative; specialist in open-pit mining; considerable experience in exploration, development, and organization of mines; speaks Spanish fluently and has successfully negotiated Latin-American contracts; construction experience on railways, port improvements, and hydro-electric plants. Now available. C-6413.

CIVIL ENGINEER; 28; single; graduate, Cornell and Missouri universities; 2 years job experience with large construction company; 3 years in tropics in responsible charge of survey and topography parties; experienced in drainage and irrigation design, field installation, and sales. Speaks Spanish. Available at once. C-1157.

CIVIL AND STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 41; graduate; 2½ years railway experience; 2 years United States land survey; 2 years military engineer; 4 years sales engineer; 8 years in design of structural steel and reinforced concrete. Location in United States—Middle West or Southwest preferred. Best of references. C-9393.

STRUCTURAL DESIGNER; Assoc. M. Am. Soc. C.E.; 33; graduate; married; 9 years experience—6 months teaching mathematics; 2½ years city planning; 6 months railroad electrification; 3 years state highway bridge design; 2½ years railroad bridge design. Eastern States and New York City preferred. B-6280.

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; single; 2 years experience highway surveying and drafting; 2 years experience with public utility as surveyor and field engineer, selecting routes for new telephone lines, and locating and engineering same. Salary secondary to opportunity to connect with responsible engineering firm. C-6253.

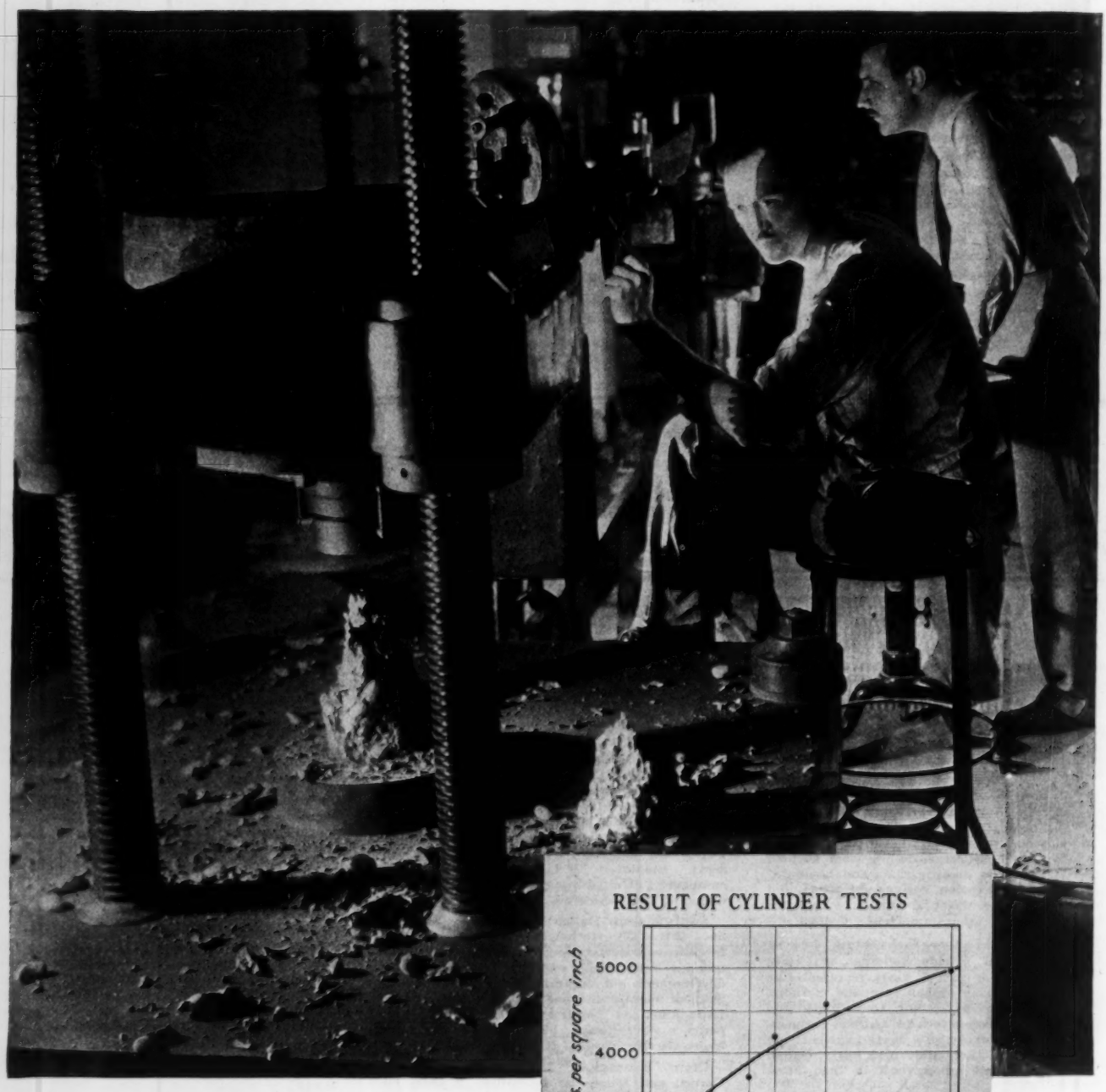
PROFESSIONAL ENGINEER AND SURVEYOR; M. Am. Soc. C.E.; licensed, New York State; college graduate; 25 years experience in engineering and allied lines—concrete and steel designs, estimates, specifications, reports, and appraisals; 7 years municipal engineering—subways, sewers, and highway improvements. Real estate mortgage loans, appraisals, plan, specifications, payments, and inspections. A-2270.

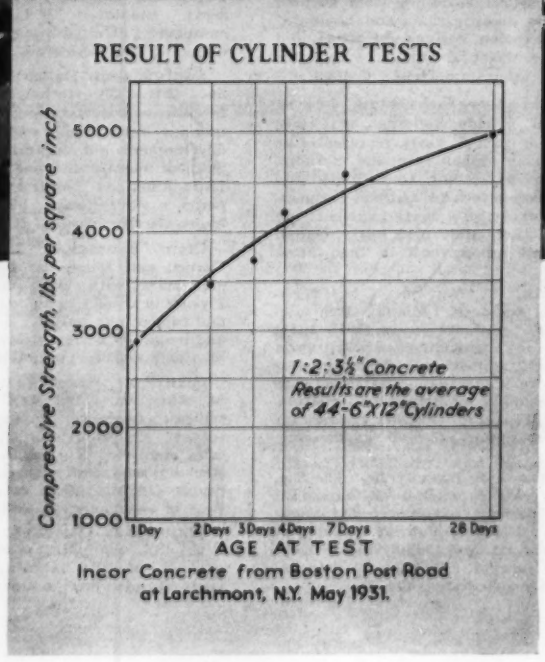
CIVIL AND INDUSTRIAL ENGINEER; M. Am. Soc. C.E.; graduate; 20 years experience in design and construction, hydro-electric developments, industrial plants, and institutional and housing groups for state and private interests, including utilities. Experience covers complete design and supervision of entire work from inception, including preliminary studies and estimates, mechanical, and architectural work. B-2835.

ARCHITECTURAL ENGINEER; Jun. Am. Soc. C.E.; 25; married; graduate, Ohio State University; 3 years experience public utilities engineering and management corporation. Location, South, Middle West, or East. Excellent references. One employer. Available on short notice. Employed at present. C-9937.

ENGINEER; 28; married; Christian; graduate, Massachusetts Institute Technology, 1925; general engineering; 7 years varied experience in investigation, design, research, reports, and construction work on hydraulic problems and hydro-electric developments for a large public utility corporation. Author of several technical articles. Has had some experience in sanitary engineering. Will consider position in any capacity C-5233.

"2940 pounds to





2940 POUNDS PER SQUARE INCH. The 24-hour old "Incor" cement concrete cylinder described on the opposite page withstood this pressure before breaking. The above photograph of the compression machine and broken specimen was taken immediately after the test.

Forty-four cylinders in all were tested, after curing under job conditions, at periods of one to twenty-eight days. The graph chart on the right shows the results.

the square inch!–

that will hold them."

Ready for traffic in 24 hours, "Incor" concrete saves local merchants $300,000

TWENTY thousand cars a day were being detoured round the main business section of Larchmont, New York, while the Boston Post Road was being repaved.

Transient trade was eliminated. Local trade was being diverted. The trade loss—more than $10,000 a day—was threatening the business life of the district.

To facilitate the job and restore normal traffic in 20 days instead of 3 months, the use of "Incor" was decided upon.

But the nights were cold and the engineers feared that sufficient strength might not be acquired in 24 hours to permit full traffic service.

BOSTON POST ROAD, LARCHMONT, N. Y. The use of "Incor"* Cement in repaving this section of highway reduced the necessary detour time at least *30 business days*, representing a saving to local merchants of $300,000.

Forty-four test cylinders were prepared on the job and cured under the same conditions as the pavement.

At the end of 24 hours 6 of these cylinders were tested. Engineers stood by as the crushing pressure was applied.

Farther and farther out on the beam moved the counterweight—past the minimum for full traffic service—past 70,000 pounds, past 80,000 pounds, until at 82,320 pounds the cylinder broke.

"TWO THOUSAND NINE HUNDRED AND FORTY POUNDS PER SQUARE INCH. *That will hold them!*" said an observer.

This 24-hour "Incor" concrete, despite cool weather, was already stronger than *any* traffic required.

Down came the barriers, down came the detour signs—and traffic took its normal course. A job that was to have taken 90 days was completed in 20.

Business came back at a bound. The Business Association and the Lions Club passed resolutions thanking the Mayor, the Engineers and the Contractor for their work.

Such was the result with "Incor" cement.

Had ordinary Portland cement been used, *under the most favorable conditions* normal traffic could not have been resumed for 30 business days longer, which at $10,000 a day would have meant an additional loss to the merchants of $300,000.

$300,000 saved at an added cost for "Incor" of $3512.

But what about the rest of the test cylinders?

Divided into 5 groups and broken at 2 days, 3 days, 4 days, 7 days and 28 days respectively, they revealed the following strengths:

At 2 days the average was 3478, at 3 days 3701, at 4 days 4181, at 7 days 4580, and at 28 days 4986, pounds to the square inch.

The graph chart on the opposite page shows the results, and represents the average of the 44 specimens.

"Incor" double burned cement contains 60% *more* tricalcium silicate and 75% *less* di-calcium silicate than ordinary Portland cements, which are single burned. That is why it makes better concrete and does the job in 24 hours instead of one or two weeks.

In 1928, "Incor" cost twice as much as Portland cement. Today the difference is so slight as to represent a small fraction of the economies it produces.

*Reg. U. S. Pat. Off.

INCOR *24-Hour Cement*

MADE BY THE PATENTED "DOUBLE BURNING" PROCESS

"INCOR" Cement is made by the producers of Lone Star Cement, under basic patents owned by International Cement Corporation, New York City

CIVIL ENGINEER AND CONSTRUCTION SUPERINTENDENT; Assoc. M. Am. Soc. C.E.; 34; desires to make permanent connection with responsible firm engaged in any legitimate business, where ability, loyalty, and hard work are appreciated. Technical graduate; 12 years varied experience—largely construction—in responsible positions, both in engineering and contracting. Pacific Coast preferred. Registered civil engineer, California. B-7375.

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 8 years varied structural experience, drafting, design, checking, inspection, and surveys on construction work. Desires connection with construction company, consultant, contractor, or architect. Capacity to assume responsibility and interest to promote productive activity. Prefers field engineering, construction, or related work. C-2605.

ENGINEERING AND SALES EXECUTIVE; M. Am. Soc. C.E.; extensive engineering and sales experience in United States and other countries; good knowledge of Spanish. In United States for past 15 years as District Manager for internationally known engineering and contracting firm. Willing to arrange interview in New York City with responsible person. C-9631.

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 35; married; 13 years experience in promotion, reports, plans, and construction, of drainage, highway, flood control, sewers, water works, and paving. Desires position in responsible charge—consulting engineer, municipal improvements, contractor, or sales. C-5705.

CIVIL ENGINEER; M. Am. Soc. C.E.; registered professional engineer, Indiana; B.S., civil engineering, 1913; graduate study, 1913–1914; graduate course in engineering administration and highway engineering, Massachusetts Institute of Technology, 1922. Construction, designing, municipal, and consulting engineer, 1914–1918. Formerly professor of civil engineering. B-6574.

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; married; 3 years experience—2 years handling materials of construction in field in connection with erection, scheduling, and progress reports, and 1 year of steam turbine design. Able to install and operate graphic systems for this kind of work or any other. Best references. Available immediately. C-8485.

CONSTRUCTION ENGINEER; Assoc. M. Am. Soc. C.E.; 38; married; graduate, Massachusetts Institute of Technology, 1921. Production, sales, estimating, purchasing, superintendent, and executive experience; past 7½ years in building construction. Available immediately. Location immaterial. Excellent references. B-5822.

CIVIL ENGINEER; 24; single; recent graduate, Rensselaer Polytechnic Institute; desires opportunity in bridge engineering, field design, or construction. Industrious worker, capable of assuming responsibility, and reliable. With railroad company during past 2 summers doing survey work. Available immediately. Location immaterial. C-9892.

CIVIL ENGINEER; young Brazilian, who is returning to his own country, would like connections. Speaks Portuguese, English, and French. C-8835.

GRADUATE CIVIL ENGINEER; graduate, Rutgers University, 1931; good scholastic record; considerable ability in drafting and stress analyses; summer experience in highway construction and surveying. Desires permanent position, preferably in southeastern New York State or Connecticut, but would accept one elsewhere. Reasonable salary. C-9883.

ENGINEER; Assoc. M. Am. Soc. C.E.; 36; degree; married; seeks connection as sales engineer, sales manager, or in investigation, report, and research work involving asphalt planking, industrial flooring, built-up roofing, membrane waterproofing, asphalt, asphalt emulsions, bridge wearing surfaces, expansion joint, concrete admixture, building materials, architectural promotion, highway engineering, public health engineering, or municipal research. B-5254.

DESIGNING AND CONSTRUCTION ENGINEER; Assoc. M. Am. Soc. C.E.; 33; experienced in heavy construction, subways, tunnels, foundations, underpinning, soil testings, estimating, bidding, scheduling, and running work. Wide contacts; best references. Desires position in executive capacity with engineering firm or university. Eastern States only. C-9867.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 28; married; 1925 graduate with advanced degree; 6 years experience in investigation and design of hydraulic projects, drainage, power, irrigation, and flood control. Desires permanent connection with power company or consulting engineer. Excellent references. Location immaterial. C-4172.

ENGINEER; Jun. Am. Soc. C.E.; 28; married; university graduate; 6 years experience in investigations, surveys, drafting, realty developments, design, and construction. In responsible charge of field crews. C-32.

ENGINEER EXECUTIVE; M. Am. Soc. C.E.; 49; experienced in all classes of excavation of earth and rock, hydraulic and dipper dredge; river and harbor improvement, railroad work, irrigation and drainage, plain and reinforced concrete. Open for a position on 30-day notice anywhere. C-3921.

RECENT BOOKS

New books of interest to Civil Engineers, recently donated by the publishers to the Engineering Societies Library, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on pages 87 to 89 of the Year Book for 1931. The statements made regarding the books are taken from the books themselves and this Society is not responsible for them.

EINFÜHRUNG IN DIE MECHANIK FESTER ELASTISCHER KÖRPER UND ZUGEHÖRIGES VERSUCHSWESEN. By R. Girtler. Vienna, J. Springer, 1931. 450 pp., illus., diagrs., tables 10 × 7 in., cloth. 29 r.m.

This textbook presents the course in elasticity and the strength of materials given by Dr. Girtler to students of engineering and technical physics at the German Technical University in Brunn. A knowledge of mechanics, higher mathematics, and vectors is assumed. The first half of the book is devoted to the general principles of experiment and theory; the second to theories of approximation for the calculation of straight beams.

GEOLOGIC INDEX OF THE PUBLICATIONS OF THE U.S. GEOLOGICAL SURVEY. By G. H. Albertson. Denver, Colo., Geological Publishing Co., 1931. 420 pp., 10 × 7 in., leather. $10.

Geologists and engineers who have occasion to consult the publications of the U.S. Geological Survey owe a debt of gratitude to the compiler of this index. It covers all the publications of the Survey and is classified by the latitude and longitude of each locality, the unit being a 30-min. quadrangle. Key maps make it easy to locate the desired entry, where all the references to the locality will be found.

HOW TO SPEND YOUR MONEY. By the late Col. Ernest McCullough. New York, Jonathan Cape and Harrison Smith, Inc., 1931. 183 pp., diagrams, charts, tables, 7½ × 5 in., cloth. $.60.

This book is of special value to the young engineer in planning his financial future. It deals with the practical side of economics from the view of an engineer with a personal interest in the things he has written. The business cycle—with up-to-date curves; the gross and living income; investment of rent money; banks, savings, and bonds; the real estate and stock markets; distribution of wages, salaries, and income; and thrift, are some of the subjects discussed.

MITTEILUNGEN DER DEUTSCHEN MATERIALPRÜFUNGSANSTALTEN. Sonderheft 17. Berlin, J. Springer, 1931. 79 pp., illus., diagrs., charts, tables, 12 × 8 in., paper. 12 r.m.

This number contains reports from German research laboratories of eleven researches into the properties of various metals. These reports include papers on the following subjects: the influence of tin upon the constitution of brasses, the influence of small amounts of other metals upon refined zinc, the aging of steel, magnesium, and its alloys, and the cold-working of duralumin.

PLASTICITY. By A. Nadai and A. M. Wahl. New York, McGraw-Hill Book Co., 1931. 349 pp., illus., diagrs., charts, 9 × 6 in., cloth. $5.

The need for a comprehensive treatise on plasticity written in the English language has long been felt by engineers and physicists. The present book meets this need by providing an authoritative account of the subject, with emphasis upon its applications to the problems of metal working, mechanical engineering, geology, and geophysics. Although this volume is based upon the author's book, *Die bildsame Zustand der Werkstoffe*, so much additional material has been added that it is practically a new work.

PRINCIPLES AND PRACTICE OF SURVEYING. 6 ed. By C. B. Breed and G. L. Hosmer. New York, John Wiley & Sons, 1931. 716 pp., illus., diagrs., charts, map, tables, 7 × 5 in., leather. $4.

In the preparation of this new edition, nearly one half of the chapters have been rewritten, and the remainder extensively revised. A brief treatment of the plane-table, an extensive description of instruments, and a detailed description of a method of surveying valuable city lots have been added. The textbook gives a comprehensive treatment of practical surveying.

TECHNICAL WRITING. 3 ed. By T. A. Rickard. New York, John Wiley & Sons, 1931. 337 pp., 8 × 5 in., cloth. $2.

Interest in correct speech has become much more widespread since Mr. Rickard's book first appeared in 1919, and many textbooks have appeared since that date. His work still remains, however, one of the most readable and best guides to the engineer who wishes to improve his power of expression. It may be recommended heartily. This new edition, prepared for the American Institute of Mining and Metallurgical Engineers, differs from the second edition only in sundry small corrections.

THEORETICAL NAVAL ARCHITECTURE. By E. L. Attwood. Revised by H. S. Pengelly. London and New York, Longmans, Green & Co., 1931. 526 pp., diagrs., charts, plates, tables, 8 × 5 in. $5.50.

This is an expansion of the author's *Textbook of Theoretical Naval Architecture*, originally published in 1899. Intended for students and for draftsmen in the offices of shipbuilders and naval architects, it aims to show how all the ordinary ship calculations can be intelligently carried out, and to give a groundwork for further progress. The rules given are illustrated by many examples.

UNDERPINNING. By Emund A. Prentis and Lazarus White. New York, Columbia University Press, 1931. 300 pp., 150 drawings and illustrations, 6 × 9½ in., cloth. $7.50.

This volume is a detailed technical description of the methods used in the underpinning of buildings and other structures, together with examples of the different types of underpinning and the application of underpinning methods to the construction of buildings and subways. The work also discusses, with specific examples, the question of when and what underpinning is required. A chapter on the theory of foundations is given, in which the latest developments in this branch of science are treated. The underpinning and foundation operations covered in this book are, in general, the most important of their kind in the world. The examples cited are taken largely from work done under the direct control of Spencer, White, and Prentis, Inc., either as contractors or as consulting engineers.

WHO'S WHO IN ENGINEERING. 3 ed. Edited by W. S. Downs and M. M. Lewis. 1931. New York, Lewis Historical Publishing Co. 1536 pp., 10 × 6 in., cloth. $10.

The third edition of this useful work of reference is restricted, in accordance with the recommendations of the advisory committee appointed by the American Engineering Council, to living American engineers who have been practising or teaching engineering for at least ten years. About ten thousand names are included, with authentic brief information regarding such professional experience as publications, education, and addresses. A geographic index is given.

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BRIDGES

CONCRETE ARCH, DESIGN. Checking of the Design of Arch Bridges, G. H. Hargreaves. *Surveyor*, vol. 80, no. 2064, Aug. 14, 1931, pp. 163–164, 3 figs. Theoretical analysis of concrete arch bridges; moments and thrust due to dead and live loads; secondary effects; influence lines for bending moments and horizontal thrust.

CONCRETE, GREAT BRITAIN. British Engineer Designs Unusual Cantilever Bridge. *Eng. and Contracting*, vol. 70, no. 9, Sept. 1931, pp. 229–232, 6 figs. Previously indexed from *Engineer*, June 5, 1931.

Through-Cantilever Bridge of Concrete Built in Scotland. *Eng. News-Rec.*, vol. 107, no. 8, Aug. 20, 1931, p. 300, 2 figs. Description of bridge having a main span of 216 ft., anchor spans of 150 ft., a 20-ft. roadway, and two 8-ft. sidewalks, crossing South Esk River at Montrose; cost of bridge about $435,000.

HIGHWAY, FLOORS. Steel Mesh Filled with Asphalt for Light-Weight Bridge Deck, P. L. Price. *Eng. News-Rec.*, vol. 107, no. 11, Sept. 10, 1931, p. 419, 2 figs. Steel mesh of 1¼ by 9/16-in. bars filled with asphalt; provides smooth non-skid surface and weight economy for Seattle bascule span; after the usual rolling, a heavy truck with solid tires was run over the deck to produce a slight cupping, effective in making a non-skid surface.

LIFT, DESIGN. Special features Used in New Lift-Span Bridges. *Ry. Age*, vol. 91, no. 5, Aug. 1, 1931, pp. 164–168, 5 figs. Features of two large lift-span bridges over the Hackensack River, west of Jersey City, N.J.—one for passenger and the other for freight traffic—which replace two swing bridges; features of lift and tower spans; special cable weight equalizers; four sources of power provided; operation interlocked with signals; foundation problems varied; dimensional details.

RAILROAD, CONSTRUCTION. Bridging the Atchafalaya Under Difficulties. *Ry. Age*, vol. 91, no. 4, July 25, 1931, pp. 123–126, 4 figs. Constructional details and methods of erection of single-track through-truss bridge, 2,336 ft. long, across the Atchafalaya River at Melville, La.; high water, deep foundations in unstable material, and obstructions in bed of river complicate the problems of construction.

STEEL TRUSS, CONSTRUCTION. Unbraced Steel Pile Bents Used to Erect Railway Truss. *Eng. News-Rec.*, vol. 107, no. 9, Aug. 27, 1931, pp. 345–346, 1 fig. Method of erection of steel-truss bridge over Youghiogheny River at Connellsville, Pa.; steel falsework demonstrated superiority over timber falsework for this structure; driving was easily accomplished with steel I-sections; truss has span of 300 ft.

SUSPENSION, HUDSON RIVER. Paving a 60-Foot Roadway in Mid-Air. *Contractors and Engrs. Monthly*, vol. 23, no. 1, July 1931, pp. 53–57, 15 figs. Materials handling, form work, and pouring methods for the concrete floor slabs of the Hudson River Bridge, New York City.

BUILDINGS

CONCRETE COSTS. Building Material and Construction Costs—II, T. F. Laist. *Gen. Bldg. Contractor*, vol. 2, no. 8, Aug. 1931, pp. 30–37, 7 figs. Form work for basement walls of minor structures; form work for footings and foundation walls of residences and minor structures; major operations; drives and walks; floors.

CONSTRUCTION. Monolithic Concrete Buildings. *Gen. Bldg. Contractor*, vol. 2, no. 8, Aug. 1931, pp. 23–26, 6 figs. Review of progress in monolithic concrete construction on Pacific Coast of the United States, with special references to practices developed in the construction of the Dominguez-Wilshire Building, Los Angeles; producing desired surface texture and ornamentation; use of fiber board.

HIGH BUILDINGS, EARTHQUAKE BRACING. Concrete Walls for Earthquake Bracing of Tall Buildings, N. Green. *Eng. News-Rec.*, vol. 107, no. 10, Sept. 3, 1931, pp. 364–366, 1 fig. Comparison shows economy of 6 per cent of the total cost of 30-story building over steel portal bracing; infrequently used concrete designs based on high shear and bond strength; stresses and structural details of rigid wall bracing for earthquake resistance; effect of earthquake bracing on steel tonnage and building cost.

OFFICE BUILDINGS, FOUNDATIONS. Difficult Steel-Cylinder-Pile Foundation Construction. N. A. Melick. *Eng. News-Rec.*, vol. 107, no. 7, Aug. 13, 1931, pp. 267–269, 6 figs. Experience in constructing the foundation for the new U.S. Government Assay Office in New York City; difficulty in driving steel-cylinder piles and in seating them on irregular rock; from 25 to 45 per cent of 12-in. piles of 3/8 and 1/2-in. shell, failed in driving; increasing shell thickness to ¼ and 7/8 in. reduced failures; at one place, piles were abandoned and timbered open pit was sunk.

STRUCTURAL STEEL WELDING. Welded Joint Carries Column Load of 380 Tons in Lobby Alteration Job, F. P. McKibben. *Eng. News-Rec.*, vol. 107, no. 10 ,Sept. 3, 1931, pp. 374–377, 4 figs. Third field-welded addition to Du Pont Building in Wilmington, Del., involves floor enlargements, addition of several stories, and lobby alterations in which double truss is inserted to pick up heavy column load at second floor through special welded connection; structural details of entrance lobby enlargement involving transfer of 760,000-lb. column load to new truss through welded connection; welding data; beam-to-column connections.

TEMPLES, CONSTRUCTION. Temple of Unique Design Taxes Ingenuity of Form Builders. *Construction Methods*, vol. 13, no. 8, Aug. 1931, pp. 46–48, 5 figs. Construction of forms for concrete work of Baha'i Temple at Wilmette, Ill.

WELDED. Helpful Facts about Arc Welding, F. P. McKibben. *Contractors and Engrs. Monthly*, vol. 23, no. 1, July 1931, pp. 61–64, 3 figs. Advantages of welded construction; applications of welding to construction of 19-story office building in Dallas, Tex.

CITY AND REGIONAL PLANNING

INDIA. New Delhi—Capital City of India, 1931. *Eng. News-Rec.*, vol. 107, no. 11, Sept. 10, 1931, pp. 413–416, 7 figs. Description of new seat of government; begun in 1913 and opened in 1931; founded in open country adjacent to ancient commercial city; monumental structures; city plan, public works, and utilities; comparison with Australia's new capital.

TRANSPORTATION. The Traffic Problem in Relation to Town and Regional Planning, G. L. Pepler. *Int. Housing and Town Planning Congress, Berlin*, 1931, pp. 32–54. General report summarizing papers presented at congress; decentralization; railways; roads; omnibuses and tramways; air transport; coordination of different forms of traffic. Article printed in same issue in English, French, and German.

CONCRETE

CEMENT DISINTEGRATION. Chemical Action of Aggressive Waters on Cement, J. O. Roos of Hjelmsaeter. *Int. Congress for Testing Materials—Advance Paper*, 1931, 22 pp., 15 figs. Dissolving and chemical action of waters and cement; laboratory methods for determining this action; results of attack of pure water and water containing bicarbonate of lime and aggressive carbonic acid on different kinds of cement and cement mixtures. Bibliography.

CONCRETE AGGREGATES, FLAT PARTICLES. Effect of Flat and Elongated Particles in Mineral Aggregates, S. Walker. *Nat. Sand and Gravel Bul.*, vol. 12, no. 7, July 1931, pp. 17–20 and 24, 2 figs. Report to Mineral Aggregates Committee, of Highway Research Board, on outline of investigation to study effect of flat and elongated particles in coarse mineral aggregates; effects on workability; strength; surface finishing and quality of surface.

CONSTRUCTION, FORMS. Effect of Vibration on the Pressure of Concrete Against Forms, L. S. Teller. *Eng. and Contracting*, vol. 70, no. 9, Sept. 1931, pp. 242–244, 5 figs. Previously indexed from *Pub. Roads*, Mar. 1931.

CONTROL. Constant Consistency as an Aid to Concrete Control, T. C. Powers. *Eng. News-Rec.*, vol. 107, no. 10, Sept. 3, 1931, pp. 368–370, 2 figs. Mixer operator's judgment of consistency is effective if aided by weight proportioning, separated aggregate sizes, and knowledge of weights to use under average moisture conditions together with a simple rule for adjusting weights when moisture in aggregates varies from average; rule for control; correction for moisture in materials; determining weight-correction factors; effect of changes in grading.

DISINTEGRATION. The Effect of Water-Gas Tar on the Strength and Alkali Resistance of Concrete, E. C. E. Lord. *Pub. Roads*, vol. 12, no. 4, June 1931, pp. 109–116, 6 figs. Treated and untreated cylinders show little difference in ultimate strength after storage in tap water; exposure tests of concrete treated with water-gas tar and coal tar and stored in alkali water, at Medicine Lake, S.Dak.; concrete of high cement content, cured for limited period in dry air and treated with water-gas tar, is capable of offering appreciable resistance to alkali attack.

MIXING. Designing Concrete for High Strength, Low Permeability, and Low Shrinkage, W. A. Slater. *Int. Congress for Testing Materials—Advance Paper*, 1931, 16 pp., 12 figs. Designing concrete for given strength and low permeability reduces to combining water and cement in predetermined proportions with aggregates in such proportions as to give workable mixes and low cost of finished concrete; moist curing has been found to be an effective measure for promoting strength, low permeability, and low shrinkage; derivation of properties with variations in compositions of mix.

RAILROADS, CONCRETE PLANTS. Railroad Plant Produces Concrete When and Where Needed. *Contractors and Engrs. Monthly*, vol. 23, no. 2, Aug. 1931, pp. 49–50, and 74, 5 figs. Use by the Pennsylvania Railroad of concrete mixing plants consisting of a mixer car and three bin cars, on electrification of road between New York and Philadelphia.

CONSTRUCTION INDUSTRY

COSTS. Current Construction Unit Prices. *Eng. News-Rec.*, vol. 107, no. 6, Aug. 6, 1931, pp. 232–233, 1 fig. Unit prices bid and a description of the following: Concrete sewers in Richmond, Va., of 120-in. horseshoe-type, and 84 in., 78-in., and 72-in. precast reinforced-concrete pipe; removing 100,000 cu. yd. of soft material and 182,200 cu. yd. of ledge rock from the Hudson River in the vicinity of Albany; contract for New Lock No. 4 in Monongahela River, Pennsylvania, let for $1,196,917; dredging channel 200 ft. wide in Saginaw River and Saginaw Bay, Lake Huron, Michigan.

Current Construction Unit Prices. *Eng. News-Rec.*, vol. 107, no. 9, Aug. 27, 1931, pp. 354–355, 2 figs. Unit prices bid and a description of Cle Elum Dam in Washington, consisting of sprinkled and rolled earth and gravel fill, with extensive blankets of earth totaling 1,235,000 cu. yd. of materials, and Charlestown Street trunk sewer in Seattle, Wash., awarded for $159,190.

Unit Bid Summary. *West Construction News*, vol. 6, no. 15, Aug. 1931, pp. 428, 432, 434, and 436. Unit prices bid and a description of the following: street, road work, and bridge construction in California, Arizona, Montana, and other Western States.

EXCAVATION, UNITED STATES. 8-Yd. Shovels Remove Hilltop to Make Terminal Fill. *Construction Methods*, vol. 13, no. 8, Aug. 1931, pp. 40–43, 7 figs. Description of borrow-and fill job, amounting to 5,500,000 yd., for the new Cincinnati Union Passenger Terminal; removing 3,000,000 yd. of rock, clay, and shale from Bald Knob, about ½ mile from site; electric well drills sink blasting holes ahead of shovels; two 8-yd. steam shovels load most of material; and two 1½-yd. machines perform railroad benching and clean-up

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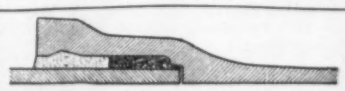

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work; contractor also uses two 1¼-yd. shovels for loading.

DAMS

CONCRETE ARCH, BIG TUJUNGA, CALIFORNIA. Big Tujunga Dam No. 1, California. *West Construction News*, vol. 6, no. 13, July 10, 1931, pp. 343–349, 8 figs. Los Angeles County Flood Control District completes first of four flood-control and conservation dams to be built in Big Tujunga Canyon and the thirteenth major dam constructed by the district; it embodies variable-radius arch with gravity section at each end and earth fill on north and adjoining spillway; i is 200 ft. high above stream bed and 251 ft. above lowest foundation; spillway is overflow weir; sill elevation 2,290 ft., and freeboard 18 ft. above spillway crest.

CONSTRUCTION. Heavy Girders Erected on High Dam, J. C. Lamon. *Eng. News-Rec.*, vol. 107, no. 9, Aug. 27, 1931, p. 345, 2 figs. During the construction of the Carpenter Dam of the Arkansas Power and Light Company, on Ouachita River in Arkansas, it was found necessary to erect gantry crane at right angles to the dam crest and at elevation 70 ft. above the base of supporting A-frame and to handle two 126-ft. plate girders, each weighing 75 tons.

Modern Dam Construction, C. M. Saville. *Water and Water Eng.* (*Special Institution Number*), vol. 33, no. 391, 1931, pp. 313–331, 10 figs. Methods and means used during the past 40 years in planning and construction; costs; the cause and prevention of failures; results attained in typical structures; résumé of dam building; examples of solid masonry dams; spillways; siphon and shaft spillways; composite dams; rock-fill and timber dams; earth dams; rolled embankments; outlet pipes. Before Inst. Water Engrs.

DEADWOOD, IDAHO. Deadwood Dam, Boise Project, Idaho, R. J. Newell. *New Reclamation Era*, vol. 22, no. 8, Aug. 1931, pp. 175–179, 3 figs. Description of concrete arch dam 160 ft. high above bedrock, having crest length of 725 ft.; clearing of reservoir and dam site; construction procedure; grouting construction joints; cost data.

EARTH, FAILURE. Corpus Christi Dam Failure, J. B. Lippincott. *Eng. News-Rec.*, vol. 107, no. 4, July 22, 1931, p. 150. Description of failure and comments on causes.

EARTH FILL, AUSTRALIA. High Earthen Dams, with Particular Relationship to the Silvan Dam for Melbourne Water Supply, E. G. Ritchie. *Inst. Engrs. Australia—Journal*, vol. 3, no. 7, July 1931, pp. 245–246, 3 figs. Discussion by E. D. Shaw, of paper previously indexed from issue of Dec. 1930.

HOOVER DAM PROJECT. Hoover Dam and Its Influence on the Southwest, E. Mead. *New Reclamation Era*, vol. 22, no. 8, Aug. 1931, pp. 162–165, 4 figs. General non-technical outline of project and its economic significance; hazards of early construction; provision for financing.

WEIRS, MOVABLE. Shutter-Weir on the Upper Seine. *Engineering*, vol. 132, no. 3421, Aug. 7, 1931, p. 166, 8 figs. partly on pp. 167 and 170. Extensive river-regulation works are in progress on the Upper Seine between Paris and Montereau; included among these has been the replacement of existing needle weir at Vives-Eaux by shutter weir of improved type; shutters are manipulated wholly by power, and only one attendant is required, due to Aubert's work.

FLOOD CONTROL

CHECK DAMS. Check Dams Control Debris Movements on Mountain Streams, L. M. Winsor. *Eng. News-Rec.*, vol. 107, no. 8, Aug. 20, 1931, pp. 290–291, 5 figs. Control of debris in Utah streams; damage from debris carried to valuable land large y eliminated by construction of inexpensive dams to form stilling pools.

FLOODS, CALIFORNIA. An Early Yuba River Flood, W. W. Waggoner. *Eng. News-Rec.*, vol. 107, no. 8, Aug. 20, 1931, p. 305. Descriptive note on 1861 flood of Yuba and adjacent streams in California, which produced unprecedented debris epo-its at mouths of mountain streams and in lower navigable waters.

FLOW OF WATER, EMBANKMENTS. Flood Flows Over Embankments, A. S. Fry and G. H. Hickox. *Eng. News-Rec.*, vol. 107, no. 5, July 30, 1931, p. 187. Discussion by G. W. Payne of article previously indexed from issue of Apr. 2, 1931.

RIVERS, REVETMENTS. Less-Used and Experimental Bank Revetment Structures, F. Y. Parker. *Eng. News-Rec.*, vol. 107, no. 8, Aug. 20, 1931, pp. 301–303, 5 figs. Description of brush and lumber mattresses and Pittman, Jacoby, and Parker revetment; essentials of successful revetment mattress; life of brush mattress; experimental revetments.

FLOW OF FLUIDS

COMPRESSED AIR LINES, PRESSURE DROP. Pressure Drop Caused by the Flow of Compressed Air in Pipe Lines Under Commercial Conditions, S. Hunt. *S. African Inst. Engrs.—Journal*, vol. 29, no. 11, June 1931, pp. 228–236, 7 figs. Author's reply to discussion of paper indexed in Engineering Index, 1930, p. 418, from issue of June 1930.

WATER PIPES. A Solution of the "Dual Flow" Problem by Graphical Analysis, G. K. Palsgrove *Am. Water Works Assn.—Journal*, vol. 23, no. 7, July 1931, pp. 960–967, 4 figs. Previously indexed from *Water Works Eng.*, July 15, 1931.

FOUNDATIONS

CAISSONS, CONCRETE. Testing Pit Sunk as Open Caisson. *Eng. News-Rec.*, vol. 107, no. 9, Aug. 27, 1931, pp. 343–344, 3 figs. Construction of machinery pit, 26 ft. in diameter and 75½ ft. deep, for testing purposes, at the plant of the A. O. Smith Corp., Milwaukee, Wis., attained by sinking concrete caisson by open excavation.

EARTHWORK, COMPUTATION. Graphical Earthwork Computation, H. T. Johnson. *Eng. News-Rec.*, vol. 107, no. 4, July 22, 1931, p. 145, 1 fig. Graphic average and area computation that gives accurate and complete solution to earthwork problems used successfully on a number of canal and road location surveys.

FOUNDATIONS, DESIGN. Theory and Design of Foundations in Black Soil, Y. D. Kumar. *Inst. Engrs. India —Journal*, vol. 10, May 1931, pp. 25–43 and (discussion) 44–66, 26 figs. Outline of author's original theory of design of foundations in treacherous soils; review of existing practice; numerical examples and suggested designs.

LANDSLIDES. Some Theoretical Considerations on Landslides. D. P. Krynine. *Eng. News-Rec.*, vol. 107, no. 9, Aug. 27, 1931, p. 347. Discussion by M. M. O'Shaughnessy, of paper previously indexed from issue of July 16, 1931.

HYDRO-ELECTRIC POWER PLANTS

RESERVOIRS, OUTLETS. The Patjal Storage Dam in Java. *Water and Water Eng.*, vol. 33, no. 393, Aug. 20, 1931, pp. 445–447, 1 fig. Installation of four tunnel sluices, 1.25 m. by 2.10 m., to operate under head of 33 m. above sill with no back-pressure, two needle valves, each 1.0 m., with "Venturi" throat 0.914 m., opening out to 1.0 m., and two double-flanged sluice valves 1.0 m.

HYDROLOGY, METEOROLOGY, AND SEISMOGRAPHY

WIND PRESSURE. Pressure of 45 lb. in Michigan Wind Storm. *Eng. News-Rec.*, vol. 107, no. 11, Sept. 10, 1931, p. 425. Data on storm of July 15, 1931; damage from storm; determination of wind pressure by testing broken dead branch of tree.

INDUSTRIAL BUILDING

FLOORS. The Factory Floor, H. S. Jacoby. *Maintenance Eng.*, vol. 89, no. 8, Aug. 1931, pp. 390–392, 1 fig. Characteristics of the following types of floors in industrial plants: concrete, asphalt mastic, asphalt block, maple, maple block (herring-bone), and wood block creosoted.

STRUCTURAL STEEL WELDING PLANTS. A Structural-Welding Fabricating Shop, H. E. Stitt. *Eng. News-Rec.*, vol. 107, no. 4, July 22, 1931, pp. 128–129, 2 figs. Description of Austin Company's Bliss Mill plant in Cleveland for straight-line production of welded fabricated steel, having monthly capacity of 1,000 tons of welded steel and 1,800 tons of riveted steel; attaching details to columns and purlins by hand welding.

IRRIGATION

IRRIGATION CANALS, LINING. Concrete Lining for Irrigation Canals in Texas, A. J. Moore. *Eng. News-Rec.*, vol. 107, no. 7, Aug. 13, 1931, p. 270. Discussion by C. L. Huff of article previously indexed from issue of Aug. 13, 1931.

PUBLIC WORKS, INDO-CHINA. Public Works in Indo-China, H. E. Babbitt. *Eng. News-Rec.*, vol. 107, no. 7, Aug. 13, 1931, pp. 253–257, 6 figs. Survey of public works expenditures and organization, railroad construction, irrigation, navigation, highways, and river control.

LAND RECLAMATION AND DRAINAGE

ROAD DRAINAGE. Need of Adequate Drainage of Road Bed, J. M. Empey. *Assn. Chinese and Am. Engrs.—Journal*, vol. 12, no. 5, May 1931, pp. 10–13. Previously indexed from *Can. Engr.*, Mar. 3, 1931.

MATERIALS TESTING

BEAMS, WELDED. Impact Load Tests on Arc-Welded and Riveted Beams, E. O. Paton and A. V. Diatlov. *Am. Welding Soc.—Journal*, vol. 10, no. 6, June 1931, pp. 39–43, 21 figs. Detailed report on tests made at the laboratories of the Kiyev Institute of Technology, Ukrainia, leading to the conclusion that welded beams offer no less resistance to dynamic than to static loading and that they offer more resistance to dynamic loads than to riveted beams.

BUILDING STONE, WEATHERING. Weathering Test Procedures for Stone, D. W. Kessler. *Stone*, vol. 52, no. 7, July 1931, pp. 386–387, 1 fig. Review of an investigation of the difficulties that may be encountered in trying to estimate durability of material from results of weathering test.

CAST IRON. Tests on Cast Iron: A Consideration of Test Results Obtained in Czecho-Slovakia, F. Pisek. *Int. Congress for Testing Materials—Advance Paper*, 1931, 19 pp., 25 figs. Czecho-Slovak Standards Association tests of 22 classes of iron; frequency curve relationships between tensile strength, shear strength, Brinell hardness, and transverse strength.

COLUMNS, CONCRETE. Stresses and Strains in Reinforced Concrete Columns, F. E. Richart. *Int. Congress for Testing Materials—Advance Paper*, 1931, 28 pp., 17 figs. Function of spiral reinforcement; relation between unit load and lateral restraint; tests of columns under rapid loading; reinforced columns held under constant design load for 5 months shortened appreciably as the result of shrinkage and plastic flow.

CONCRETE, READY-MIXED. Tests of Truck-Conveyed Centrally-Mixed Concrete. *Eng. and Contracting*, vol. 70, no. 7, July 1931, pp. 171–174, 3 figs.; see also *Roads and Streets*, vol. 71, no. 7, July 1931, pp. 267–270, 3 figs. Slump, strength, and constituents of mix investigated in experiments at Lehigh University; progressive increase in strength with time and absence of segregation noted; cement content of mix found to increase throughout run.

MACHINES, PRECISION. Accuracy of Measurement and Variability of Test Results, F. C. Lea. *Int. Congress for Testing Materials—Advance Paper*, 1931, 7 pp. Modern testing machines yield degree of accuracy which exceeds homogeneity of specimens taken from same ingot; accuracy of extensometers; time function in testing of materials; high temperatures and repetition tests.

METALS, WEAR. The Wear of Metals, L. Jordan. *Mech. Eng.*, vol. 53, no. 9, Sept. 1931, pp. 644–650, 3 figs. Preliminary analysis of problem in which it is suggested that wear takes place by abrasion, by erosion, and by galling; importance of wear in engineering design and service; methods of protection against wear; methods available for making laboratory measurements of wear resistance.

REFRACTORY MATERIALS. The Application of Tensile Tests to the Study of the Bonding of Refractory Materials, J. H. Chesters and W. J. Rees. *Ceramic Soc.—Trans.*, vol. 30, no. 7, July 1931, pp. 258–267, 4 figs. Results of cold tensile tests on certain dried and burned materials; apparatus for heating rod to 1,000 deg. cent. under constant tension, and recording extension; stability ranges of certain organic and inorganic bonds.

STEEL FATIGUE. Failure of Steel in Machine Parts, L. T. Holt. *Steel*, vol. 89, no. 8, Aug. 20 1931, pp. 31–33, 9 figs. Notch fatigue, insufficient heat treatment, tool marks, and presence of inclusions are considered as some of the principle causes of failure. Before West. Metal Congress.

STEEL, TEMPERATURE EFFECT. The Yield Point and Creep Limit of Steel at High Temperatures, V. B. Harley-Mason. *Engineering*, vol. 132, no. 3422, Aug. 14, 1931, pp. 203–204. Previously indexed from *Engineer*, July 31, 1931.

PORTS AND MARITIME STRUCTURES

CALIFORNIA. The Ports of Los Angeles and Long Beach, California. *U.S. Corps. Engrs.—Port Series*, no. 13, part 1, 1931, 234 pp., numerous figs. and maps on supp. plates. General description of ports and harbor conditions; port customs and regulations; services and charges; fuel and supplies; port and harbor facilities; communication facilities.

CALLAO, PERU. Terminal Developments at Callao, Peru, R. Cremer. *World Ports*, vol. 19, no. 9, July 1931, pp. 977–997 and (discussion) 997–1002, 5 figs. General description of ports; engineering data; considerations of design; locations; breakwaters; piers; customs and storage warehouses; docks; construction operations.

CANTON, CHINA. Canton—A World Port. *Far East Rev.*, vol. 27, no. 6, June 1931, pp. 352–358, 16 figs. partly on supp. plates. Reclamation work, bridge construction, public utilities, building operations, water supply, and plan for deep harbors.

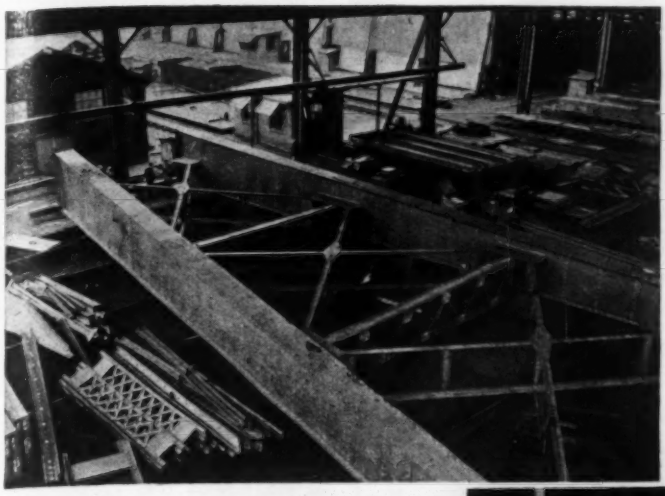
LIGHTHOUSES, CANADA. The Lighthouse Service of Canada, J. G. Macphail. *Eng. Journal*, vol. 14, no. 8, Aug. 1931, pp. 446–451, 11 figs. Organization of service; descriptions of various lighthouses. Before Eng. Inst. Canada.

PORT TERMINALS, PORTLAND, ME. Modern Tidewater Terminal at Portland, Me. *Eng. News-Rec.*, vol. 107, no. 7, Aug. 13, 1931, pp. 258–261, 8 figs. Design and construction of new wharves at a cost of $2,000,000; special equipment for handling baled pulp, pulpwood, china, clay, coal, and sulfur; 129-ft. wood piles required for coal dock.

PORTLAND, ME. The Port of Portland, Me. *Naut. Gaz.*, vol. 121, no. 2, July 11, 1931, pp. 6–9 and 24, 8 figs. Railroads serving Portland; State Pier; Portland Terminal Company; receiving, classification, and departure yard at Rigby; port facilities.

PORTS, AMSTERDAM. The Port of Amsterdam, L. Boogerd and J. E. van Heemskerck. *Dock and Harbour Authority*, vol. 11, no. 130, Aug. 1931, pp. 301–313, 33 figs. Brief history of port, port facilities, recent improvements, and construction of quay walls. (To be continued.)

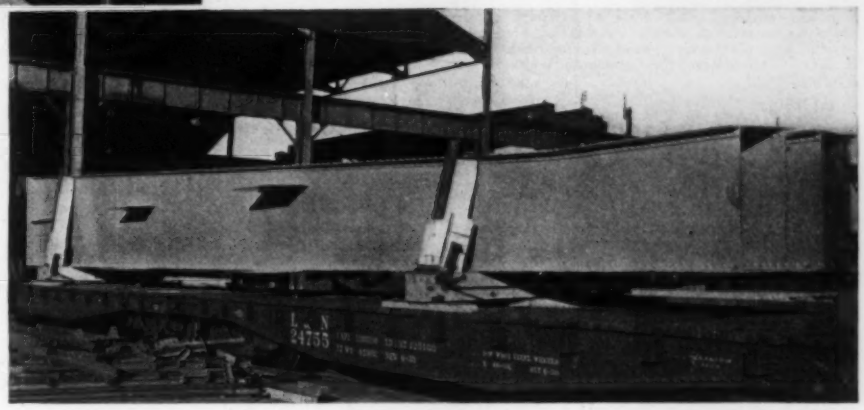
RIVER, CONSTRUCTION. Bulkheads Retain New Fill at Point Breeze, Md., H. G. Dean and F. W. Daniels. *Eng. and Contracting*, vol. 70, no. 9, Sept. 1931, pp. 221–224, 6 figs. Construction of 7,000 ft. of bulkhead at the Point Breeze Works of the Western Electric Company.



VIRGINIA BRIDGE

Steel Structures

These two pictures show sections of the main steel work being manufactured and shipped from our Birmingham Plant for the 350-ton Gantry Crane built by the Whiting Corporation for the Ariel Dam, Woodlawn, Wash. Below is the completed crane in operation. Phoenix Utility Co., New York, Engineers.



GRIST TO THE MILL

Our plants do many different kinds of steel construction besides steel bridges and buildings. If you want it built of steel we can do it and likely have.

From Birmingham, Ala., to Woodlawn, Wash., was quite a step, but in distance only. Manufacture of the steel for this 350-ton crane presented no unusual difficulties to our facilities and organization.

We have had many years experience on many different kinds of work, and shall be glad to give you our best thought on your problems of design and construction, steel or possible steel.

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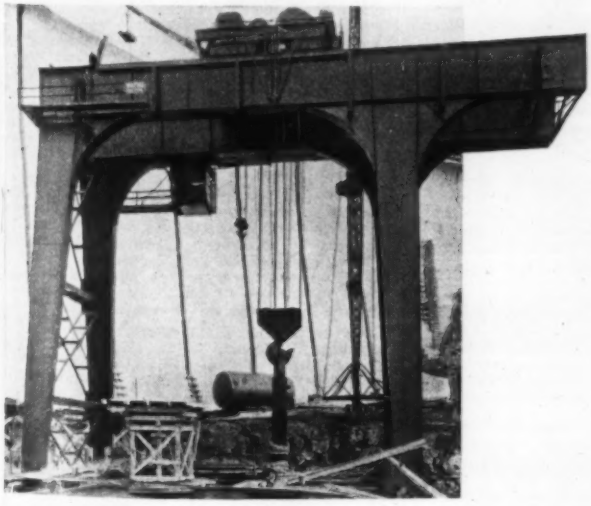

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SEA WALLS, CONSTRUCTIONS. Sea Wall Construction Costs and Data, J. A. Young. *Surveyor*, vol. 80, no. 2064, Aug. 14, 1931, pp. 165–167. Steel sheet piling; extracting sheet piling; timber piling; concrete piling; construction; precautions against damage to trench timbering; manufacture of facing blocks.

RAILROADS, STATIONS, AND TERMINALS

RAMPS. Cement Pressure-Grouting Stops Settlement of Ramp Piers in Fill, M. Taylor. *Eng. News-Rec.*, vol. 107, no. 8, Aug. 20, 1931, pp. 299–300, 2 figs. Methods of consolidation by grouting of settling foundations of the reinforced-concrete structure supported on 9 pairs of piers, 50 ft. center to center, with abutment 54 ft. long at lower end; Francois cementation process.

RETAINING WALLS, CONCRETE. Precast Concrete Cribbing for Retaining Walls. *Eng. News-Rec.*, vol. 107, no. 9, Aug. 27, 1931, p. 346, 1 fig. In widening the Chicago and Northwestern Railway for additional tracks, at its new express terminal in Chicago, concrete crib walls were used to retain widened fill at property line, to expedite work, and to avoid cost of monolithic concrete.

TERMINALS, CHICAGO, ILL. Large Suburban Terminal Built for Illinois Central Railroad. *Eng. News-Rec.*, vol. 107, no. 10, Sept. 3, 1931, pp. 360–362, 4 figs. Chicago suburban terminal, independent of and distant from main-line terminal station, is built into steel framing of new viaduct, making triple-deck structure; viaduct floor forms roof of station, which in turn spans tracks and platforms; final development with tracks; expansion joint prevents leakage into station.

TURNTABLES, DESIGN. A New Type of Locomotive Turntable. *Ry. Gaz.*, vol. 55, no. 3, July 17, 1931, p. 77, 1 fig. Mundt turntable, supported on end track wheels as well as ball-bearing center, designed to overcome difficulty of deep turntable; operating features.

ROADS AND STREETS

AIRWAYS, MARKINGS. Highways Marked for Airway Traffic. *Construction Methods*, vol. 13, no. 8, Aug. 1931, p. 29, 3 figs. Installation of 132 huge air-markers on pavements of principal highways throughout Ohio.

BITUMINOUS MACADAM. Use of Bituminous Macadam in Developing a Highway Program, W. R. Neel. *Highway Engr. and Contractor*, vol. 39, no. 1, July 1, 1931, pp. 47–51, 12 figs. Importance of proper base and efficient drainage is stressed.

BRICK. Choose Paving Brick for Extra Heavy Wear, Use Steel Grating Filled with Brick Cubes. *Brick and Clay Rec.*, vol. 79, no. 3, Aug. 11, 1931, pp. 126–127, 3 figs. Details of construction; test results; applicability to vehicular tunnels; enameled brick for traffic lanes.

CONCRETE, FROST DAMAGE. Studies of Frost Heaves in Michigan, A. C. Benkelman. *Roads and Streets*, vol. 71, no. 7, July 1931, pp. 272–276, 5 figs. Results of frost action determined by field studies and laboratory work; danger of soil pipes; classification of frost heaves; conditions favorable to heaving; practical application of results of study.

CONSTRUCTION. North Carolina Sand-Asphalt Paving Methods, W. E. Hawkins. *Roads and Streets*, vol. 71, no. 8, Aug. 1931, pp. 304–306, 7 figs. Necessity for careful grading of sand for this type of road; character and separation of subgrade is important factor; details of construction methods.

The Laying of Single-Coat Asphalt, A. C. Hughes. *Surveyor*, vol. 80, nos. 2061 and 2062, July 24, 1931, pp. 87–89, and July 31, pp. 111–112, 4 figs. History of asphalt mixtures; principles of bituminous construction; foundations; contour and surface of base; transport; preparation for reception of asphalt; preparation of joints; spreading; rolling; joints; layout of work; tools.

HIGHWAY SYSTEMS, FINLAND. The Finnish Highways and Their Maintenance, E. W. Skogstroem. *Surveyor*, vol. 80, no. 2065, Aug. 21, 1931, pp. 187–189, 5 figs. Description of system having a total length of 24,000 km.; transfer of highways to government; significance of highway reform; development of highway system; maintenance of present highways; and cost of highways.

ROAD CONSTRUCTION, MASSACHUSETTS. Sand-Asphalt Roads, Cape Cod, Massachusetts, C. S. Hill. *Eng. News-Rec.*, vol. 107, no. 11, Sept. 10, 1931, pp. 417–418, 3 figs. Observations on 500 miles of roads built of mixed local sand and asphalt, carrying heavy tourist traffic of resort region; spreading sand-asphalt surface mixture; construction practice; traffic; cost and upkeep.

ROAD SURFACE TREATMENT, OILING. Road Oils—I, G. M. Mullins. *Nat. Petroleum News*, vol. 23, no. 32, Aug. 12, 1931, pp. 43–45. History of road oiling; types of roads which should be oiled; minimum and maximum traffic loads for successful oil surfacing.

STONE. Broken Stone Roads, G. W. McClain. *Highway Engr. and Contractor*, vol. 39, no. 1, July 1, 1931, pp. 52–55, 4 figs. Errors often made in constructing roads of this type; importance of proper grading and drainage of roadbed and fallacy of building narrow, high-crowned, one-lane roads of broken stone which are difficult to widen.

SWAMPS. Speeding the Settlement of Fill Over Muck by the Use of Explosives. *Contractors and Engrs. Monthly*, vol. 23, no. 1, July 1931, pp. 47–48, 1 fig. Use of subsurface blasting for rapid settling of highway embankment fills to firm bearings in marshy locations.

SEWERAGE AND SEWAGE DISPOSAL

FILTERS, MATERIALS. Specifications for Slag for Trickling Sewage Filters, C. C. Hommon. *Eng. News-Rec.*, vol. 107, no. 10, Sept. 3, 1931, p. 362. Abstract of report made to National Slag Assn., Cleveland, Ohio; sampling; durability; size and gradation.

MAINTENANCE AND REPAIR. Strengthening a Failing Sewer Without Disturbing the Street Surface, W. B. Thistlewood. *Am. City*, vol. 45, no. 2, Aug. 1931, pp. 99–100, 4 figs. Method used in threading corrugated iron pipe through failing sewer, 12 ft. under surface of street in Cairo, Ill.

TUNNELS, CONSTRUCTION. A Horseshoe-Section Tunnel for a Gravity Sewer and Other Utilities. *Contractors and Engrs. Monthly*, vol. 23, no. 2, Aug. 1931, pp. 71–74, 8 figs. Construction operations on tunnel approximately 6,800-ft. long in West Orange, N.J.

STREET CLEANING AND REFUSE DISPOSAL

REFUSE INCINERATORS, OPERATION. Data on English Incinerator. *Eng. News-Rec.*, vol.107, no. 101, Sept. 3, 1931, p. 378. Previously indexed from *Surveyor*, July 24, 1931.

STRUCTURAL ENGINEERING

COLUMNS, STRESSES. Bending Moments and Shear Forces (due to wind forces) on Columns in Single-Story Buildings, G. J. Voce. *Structural Engr.*, vol. 9, no. 8, Aug. 1931, pp. 271–277, 4 figs.

STEEL CONSTRUCTION. Determining Height of Blocking for Short-Span Steel Trusses, P. Andersen. *Eng. News-Rec.*, vol. 107, no. 9, Aug. 27, 1931, p. 343, 1 fig. Formula giving amount of blocking-up necessary in erection.

TRUSSES, END CONNECTIONS. Correcting Eccentric End Connections of Old Trusses, J. K. Campbell. *Eng. News-Rec.*, vol. 107, no. 11, Sept. 10, 1931, pp. 423–424, 1 fig. Eccentric end connection of truss corrected by lowering center of gravity of top chord.

SURVEYING

HYDROGRAPHIC SURVEYING. The Physical Basis of Modern Hydrographic Surveying, A. L. Shalowitz. *Nat. Academy Sciences—Proc.*, vol. 17, no. 8, Aug. 15, 1931, pp. 445–455, 3 figs. Hydrographic surveying as practised by the U.S. Coast and Geodetic Survey; utilizing sound as a means of measuring ocean depths and distances; radio-acoustic position finding; determining the mean velocity of sound wave between vessel and shore; computation of theoretical velocities; comparison of experimental velocities with theoretical velocities for various paths.

TEXAS. Rapid and Accurate Mapping in Semi-Arid Regions of Texas, J. E. Goddard. *Eng. News-Rec.*, vol. 107, no. 6, Aug. 6, 1931, pp. 210–212, 4 figs. Standards of accuracy and methods of procedure used in surveying 153,736 acres for irrigation development in lower Rio Grande Valley; work done by contract; independent check lines run.

TUNNELS

CONSTRUCTION. Owyhee Irrigation Project Tunnels, P. Schuyler. *West. Construction News*, vol. 6, no. 14, July 25, 1931, pp. 369–380, 11 figs. Contractor established world's record in tunnel excavation on Owyhee irrigation project, Oregon-Idaho, with 1,315 lin. ft. of 11-ft. tunnel in 31 days; 63 ft. excavated in one day; description of tunnel-driving equipment and methods of driving; comparison of tunnel lining with concrete; concrete mixing plant; concrete placing equipment.

RAILROAD, CONSTRUCTION. Notes on Tube Railway Construction, H. G. Salmond. *Gov. India Tech. Paper*, no. 278, Apr. 1931, 42 pp., numerous figs. partly on supp. plates. Review of underground tunnel work procedure together with computations and examples.

WATER SUPPLY TUNNELS. Water Works Construction, M. R. Barnett. *Water and Water Eng.*, vol. 33, no. 393, Aug. 20, 1931, pp. 432–435, 3 figs. Lining of tunnels; transverse sections of various water works tunnels; brick lining for facing. (Continuation of serial.)

WATER PIPE LINES

CAST IRON. Century-Old Cast Iron Water Main, S. M. VanLoan. *Am. Water Works Assn.—Journal*, vol. 23, no. 7, July 1931, pp. 993–994. Examination of a section of the 6-in. cast-iron water pipe which has been in active service in the distribution system of Philadelphia since 1831.

CLEANING. Scraping and Electrical Recoating of Water Mains. *Water and Water Eng.*, vol. 33, no. 393, Aug. 20, 1931, pp. 435–436. Description of the pipe cleaning method developed by Eric Engineering Company, Chepstow, Mont.

CONSTRUCTION. The Construction of Modern Water Mains, F. W. Macauley. *Water and Water Eng.* (*Special Institution Number*), vol. 33, no. 391, 1931, pp. 301–308, 1 fig. Requirements and forms of construction; life history of cast iron and steel mains of Birmingham Water Committee, 42 in. in diam., 17 miles in length; composite pipes; diagram showing progressive deterioration of discharge capacity of mains; concrete-lined steel pipes; concrete-lined cast-iron pipes; asbestos cement pipes.

PROTECTIVE COATINGS. Cleaning Pipe with Air Blast and Steel Filings, R. M. Hutchison. *West. Gas*, vol. 7, no. 9, Sept. 1931, pp. 31 and 56, 3 figs. Equipment and practice, developed by Houston Natural Gas Company, for preparing pipe lengths prior to application of protective coating and wrapping.

WATER PUMPING PLANTS

HYDRAULIC MACHINERY CAVITATION. Maintenance by Electric Welding Machines, A. S. Robertson. *Contract Rec.*, vol. 45, no. 35, Sept. 2, 1931, pp. 1053–1055, 4 figs. Application to turbine runners; cavitation or pitting; experience of Ontario Hydro Commission; stainless steel experiments.

PUMPS, STEAM. Steam Piston Pumps in Germany, E. Immerschitt. *Water and Water Eng.*, vol. 33, no. 392, July 20, 1931, pp. 377–379, 7 figs. Description of several recently developed types of heavy-duty pumping engines designed for water-supply service.

WATER RESOURCES

LONDON. The Receding Water Table Below London and Northern Surrey, A. B. Buckley. *Engineering*, vol. 132, no. 3423, Aug. 21, 1931, pp. 233–235, 2 figs. While springs and wells today draw up to 19 per cent of the Metropolitan Water Boards requirements from the chalk water system, the latter suffers further depletion by abstractions through numerous privately owned wells; continued depletion of chalk water must affect sources of streams.

REGINA, SASK. Underground Water Supply at Regina, E. W. Bennison. *Can. Engr.*, vol. 61, no. 6, Aug. 11, 1931, pp. 7–11, 7 figs. Improved development of water supply and construction of Kelly concrete wells.

SOUTH DAKOTA. South Dakota Water Supplies, W. W. Towne. *Am. Water Works Assn.—Journal*, vol. 23, no. 7, July 1931, pp. 1041–1046. Underground waters of South Dakota; geology of water-bearing formations; quality of supplies; surface water sources of South Dakota; rainfall; seasonal variation in Vermilion River mineral content.

WATER TREATMENT

ACTIVATED CARBON. Experience with Powdered Activated Carbon, M. Pirnie. *Water Works Eng.*, vol. 84, no. 17, Aug. 26, 1931, pp. 1219–1220. Methods of applying powder; points of application; experiments at Luke, Md.; applying carbon en route to filters; removal of tastes and odors.

FLORIDA. Boca Raton Water Treatment Plant, H. S. R. McCurdy. *Am. Water Works Assn.—Journal*, vol. 23, no. 7, July 1931, pp. 1034–1040, 1 fig. General survey of plant constructed for an immediate capacity of 500,000 gal. per day; description of plant, re-carbonization and filter equipment; analyses of Boca Raton water; cost of plant $55,000.

WATER WORKS ENGINEERING

DRILLING. The Sinking of Borings, H. A. P. Heterington. *Water and Water Eng.* (*Special Institution Number*), vol. 33, no. 391, 1931, pp. 332–337, 9 figs. Percussion or drop boring; rotary or core boring; verticality; lining of borings; testing; increase of supply. Before Inst. Water Engrs.

STANDARDIZATION. Annual Report of Committee on Water Works Practice, for the Year 1930. *Am. Water Works Assn.—Journal*, vol. 23, no. 7, July 1931, pp. 1017–1033. Abstracts of report of standing technical committees, standard methods of water analysis; electrolysis; boiler feedwater studies; American standards for cast-iron pipe and special castings; manhole frames and covers; plumbing equipment; pipe threads; pipe flanges and fittings; code for pressure piping; wrought iron and wrought steel pipe and tubing.

WATER TANKS, ELEVATED. Unique Water Tank for Indianapolis Suburb, S. G. Roberts. *Compressed Air Mag.*, vol. 36, no. 9, Sept. 1931, pp. 3576–3578, 5 figs. Elevated tank capable of holding 1,500,000 gal., technically known as radial-cone-bottom type, developed to furnish large capacity with relatively small variation between uppermost and lowest water levels.

WATER WELLS, CALIFORNIA. Deep Wells in Southern California, A. D. Lane. *Am. Water Works Assn.—Journal*, vol. 23, no. 8, Aug. 1931, pp. 1138–1143, 1 fig. Survey of conditions in Los Angeles district, brought about by the near exhaustion of upper underground water supply strata; types of wells now in vogue; logs of wells; preparation of wells; development of wells with air; amount of development necessary.